HUMAN RESPONSES TO CLIMATE CHANGE DURING THE YOUNGER DRYAS IN NORTHWEST EUROPE

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September 2017

This dissertation is submitted to the University of Cambridge for the degree of Doctor of Philosophy

This dissertation is the result of my own work and includes nothing which is the outcome of work done in collaboration except as declared in the Preface and specified in the text.

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It does not exceed the prescribed word limit for the Degree Committee of the Faculty of Archaeology of 80000 words.

Words: 79,958

I would like to thank my supervisor Dr Philip Nigst for all his advice and support throughout my PhD, which without, this thesis would not have been possible. I would also like to thank my advisor Dr Preston Miracle for his always insightful input and to the AHRC who funded this research.

Finally, I would like to thank my parents Anne and Derek Andrews for their fantastic support and generosity, and to my partner Vilija Mostytė for her patience and kindness.

Abstract

This study discusses the extent to which hunter-gatherer mobility strategies are changed by abrupt climate change events by monitoring changes in lithic assemblage compositions through the Pleistocene/Holocene Transition, from ca. 14,000 cal BP to 10,000 cal BP in northwest Europe, with a focus on the Younger Dryas stadial event, which occurred around 12,900 cal BP to 11,700 cal BP. A set of predicted archaeological indicators were formed from existing theoretical models, based largely on Binford's logistical and residential mobility model, with the expectation that a more residential mobility strategy would be used by hunter-gatherer-populations during warmer climatic phases (i.e. the Allerød and Preboreal) and a more logistical mobility strategy would be used during cold climatic phases (i.e. the Younger Dryas). The lithic assemblages from sites across northwest Europe were then compared with these expectations in order to determine if a shift from a more residential strategy to a more logistical strategy can be seen from the lithic record. Additionally, a further comparative dataset was collected from south Europe in order to determine if there were differences in the response to the Younger Dryas at lower latitudes where the impact of this event is assumed to be less severe. The results found that in northwest Europe there is evidence to suggest there was indeed a shift from a more residential strategy during the warm Allerød interstadial to a more logistical strategy during the Younger Dryas Stadial, and the adoption of a more residential strategy with the return of warmer conditions during the Preboreal. However, it appears that the Preboreal Interstadial shows significant differences between the Allerød Interstadial, with the Preboreal sharing more characteristics in common with the Younger Dryas. This has been interpreted as a response to the unstable climatic conditions reported from the environmental evidence in this region during the Preboreal, which may have limited the ability of hunter-gatherer populations to return to similar levels of residential mobility seen during the Allerød.

The south Europe dataset provides evidence that the lesser impact of the Younger Dryas at lower latitudes brought about a more muted response by hunter-gatherer populations to this event when compared with the northwest. However, there appears to be a reversal of that seen in the northwest, with more logistically mobile populations during the Allerød and especially the Preboreal, and more residentially mobile populations during the Younger Dryas.

This is despite the environmental evidence showing a very similar environmental response to the northwest, with a distinct opening of the landscape during the Younger Dryas. The apparent difference in mobility strategies appear to be more related to the available faunal species within a region and their behaviour within their environment rather than directly to the climate. In the south, species such as red deer and ibex are the main source of faunal subsistence throughout the Pleistocene/Holocene Transition, unchanged by shifts in temperature and environment, but the way in which hunter-gatherers would hunt such species would be expected to change in more wooded environments compared with more open environments. If we compare this with the northwest, there is evidence of a distinct change from hunted prey, such as red deer, during the Allerød and Preboreal, to reindeer and horse during the Younger Dryas (although faunal preservation is poor in this region). With this shift to a more mobile prey species, along with a harsher, more open environment it may be more suitable to practise a more logistical strategy. Additionally, the instability of the Preboreal may have also changed the environment on a smaller scale, which would have required the hunting of warmer climate prey in shifting local environments, much like that of the Younger Dryas in south Europe. This might explain the differences seen between the Allerød and the Preboreal.

Overall, there appears to be strong evidence supporting the theory that colder, harsher climates promote a more logistically mobile response from hunter-gatherer populations as seen in the northwest of Europe, and that there was a more muted, different response to the Younger Dryas in the lower latitudes of south Europe. However, it is the opinion here that changes in human mobility are not controlled directly be climatic conditions, rather controlled by the available major prey species and their behaviour in changing environments.

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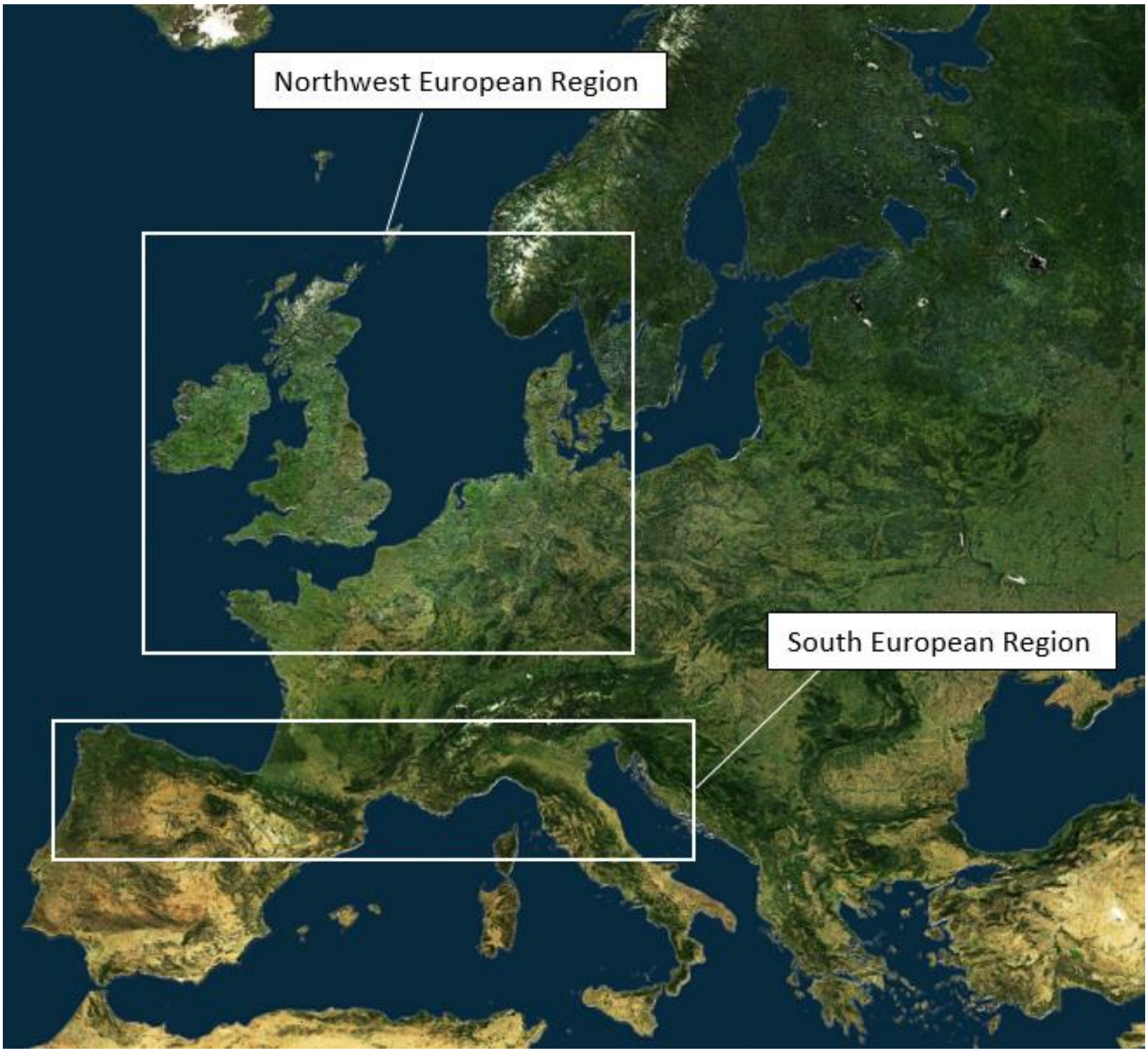
Introduction

There has long been the assumption that largescale climate change events have been a major causation of hominin behavioural change, either biologically or culturally, in early prehistory (Calvin, 2002; Hetherington and Reid, 2010; Lahr and Foley, 1998; deMenocal, 2011); have been hypothesised as the causation of the displacement and even decline and regional extinction of Neanderthals in more northerly regions of their range in Europe (Mellars, 1998; Hublin and Roebroeks, 2009); and has also often been described as a major factor in anatomically modern human cognitive evolution, where complex art, tools, and group interactions occurred as a possible responsive strategy (Banks et al., 2013; Verpooten and Nelissen, 2010). In more recent prehistory, the Last Glacial Maximum (LGM) ca. 25-18kBP, has been widely thought of as driving human populations out of large parts of northern-western Europe, with many believing that there was a drastic reduction in population and mass migrations into more southerly regions to escape the oncoming glacial ice sheets, possibly affecting our genetic evolution (Tallavaara et al., 2015; Andel and Davies, 2003; Lahr and Foley, 2003; Straus, 1991). However, these events lasted for thousands of years, and determining whether these changes were the direct result of climate change seems dubious, especially with the error ranges in radiocarbon (C^{14}) dating in earlier prehistory. There may have been many other factors in play which led to many of the cultural changes we see during the LGM.

This study attempts to identify how humans responded to major climatic events by observing changes in their mobility strategies, interpreted from their material remains. The decision was to focus on the Younger Dryas (YD) event in northwest Europe (ca. 12,900-11,700 cal BP), in which there was an abrupt, and short-lived, climatic shift to near-glacial conditions from the previous climatic upturn from the LGM. It is thought that the abrupt nature of this event, that took only a matter of a century to shift from climatic and environmental conditions near to that of today, to near glacial conditions, would be an outstanding candidate to more reliably assess to what degree major climate change events affect hunter-gatherer populations. This event also has the advantage of being the most reliably dated major climatic episode in human history, although a plateau in the C^{14} calibration curve at its terminal phase complicates dating assemblages from the transitional phase to the Holocene. This study has focused on the area of northwest Europe encompassing the U.K., northern France, Belgium, The Netherlands, northern Germany, Denmark, and western Sweden (Fig i1), where the conditions of the YD stadial would be at its most severe in the western European region that is the focus of this study, and thus assumed would have had the greatest impact on hunter-gatherer populations.

This study aimed to create a robust set of expectations to predict how hunter-gatherers organised themselves within the landscape, and use these expectations to indicate mobility change in response to the climatic and environmental changes during the Pleistocene/Holocene Transition, using only their material record. As large parts of northwest Europe, within the proposed study area, have poor organic preservation due to sandy soils, and thus very few sizeable faunal assemblages, the decision was made to focus solely on their stone tool assemblages, which are well preserved in the region. Therefore, these predictions will focus on how stone tool assemblages would be characterised in warm climate and cold climate environments based on the large body of literature discussing theories and models on hunter-gatherer mobility. From this set of predictions, indicators from the archaeological record will be put forward to compare the stone tool assemblages of hunter-gatherer populations in northwest Europe from before, during, and after the YD, in order to observe any possible changes in the characteristics of the assemblages, and thus mobility, that could be related directly to climatic and environmental change.

To achieve this, a comprehensive dataset of stone tool assemblage inventories will be collected from site reports and various publications from sites in the northwest European region in order to test these predictions and ascertain what type of mobility strategies were employed, and to what extent they changed, in response to the YD. Additionally, a further, smaller, comparative dataset will be collected from the south European region, in order to observe the differences in hunter-gatherer responses in an area assumed to be less directly affected by the YD. This region will encompass northern Spain, southern France, northern Italy, and Croatia (Fig i1). It is expected, that whatever the human mobility response to the YD in the northwest, the response in the South would be more subdued (Jones, 2016).



(Fig i1: Map of Europe showing the northwest and southern regions focused upon in this study (modified map image from Envisat satellite, European Space Agency, 2007))

This study looks to address a number of research questions, which are as follows:

- What was the extent of the climatic and environmental changes in response to the YD in northwest and southern Europe?
- How can one predict potential changes in hunter-gatherer mobility in prehistory from the archaeological record?
- What are the predicted mobility strategies of hunter-gatherer populations in warm and cold climates?
- What indicators within hunter-gatherer stone tool assemblages are suitable for determining changes in mobility?

- How do hunter-gatherer populations respond in terms of mobility to the YD in northwest Europe through evidence from their stone tool assemblages?
- To what extent do hunter-gatherer populations respond differently in lower latitudes in southern Europe, where the effects of the YD were less pronounced?
- How do hunter-gatherer populations respond to the YD event globally, based on current research and how do the results of this study agree or disagree with this current knowledge?
- What indicators within hunter-gatherer stone tool assemblages are suitable for determining changes in mobility?

In order to address these questions, the following chapters will systematically approach the key topics relating to climatic and environmental change and mobility, and then present and discuss the results of this study.

Chapter 1 will discuss the climatic and environmental changes that occurred during the Pleistocene/Holocene Transition from the Allerød Interstadial, to the YD Stadial, and into the Preboreal (PB) Interstadial. Firstly, a comprehensive synopsis of the climate and environment in the main northwest region will be presented, followed by a brief synopsis of climate and environment in the comparative South region. This will provide a framework in which to understand the environments in which hunter-gatherers existed, and thus inform the expectations and predictions discussed and formulated in Chapter 2.

Chapter 2 will provide an overview of the current theories and models, both archaeological and anthropological, for hunter-gatherer mobility, assess which theories are applicable to observing changes in stone tool assemblages, and create a methodology for indicators of mobility change based on stone tool assemblages. This methodology will be applied, in Chapters 4, 5, and 6, to the assemblages in the collected databases.

Chapter 3 will then evaluate the northwest dataset (which will form the main focus of analysis) in order to test the reliability of the data and to assess any possible sources of bias. Any such sources will be addressed, where possible, so that the results produced will be robust enough from which to make reliable interpretations. As the southern dataset is a smaller sample collection of sites for the purposes of comparison, it was considered unnecessary to evaluate this set in such detail, as it is already under the assumption that bias will be introduced due to low sample sizes in this dataset.

Chapters 4 and 5 will then present the results of the analysis of the main northwest dataset and comparative south dataset, using the methodology set out in Chapter 2, while Chapter 6 will compare the two sets of analyses from Chapter 4 and Chapter 5 in order to identify any differences in hunter-gatherer behaviour between higher and lower latitudinal regions.

Finally, Chapter 7 will discuss the results of the analyses, in terms of the research questions proposed here, to determine how human populations organised their settlement strategies. Comparisons will be made with other studies in Western Europe, and then globally, to see how these results agree or disagree with the global body of research into human responses to the YD.

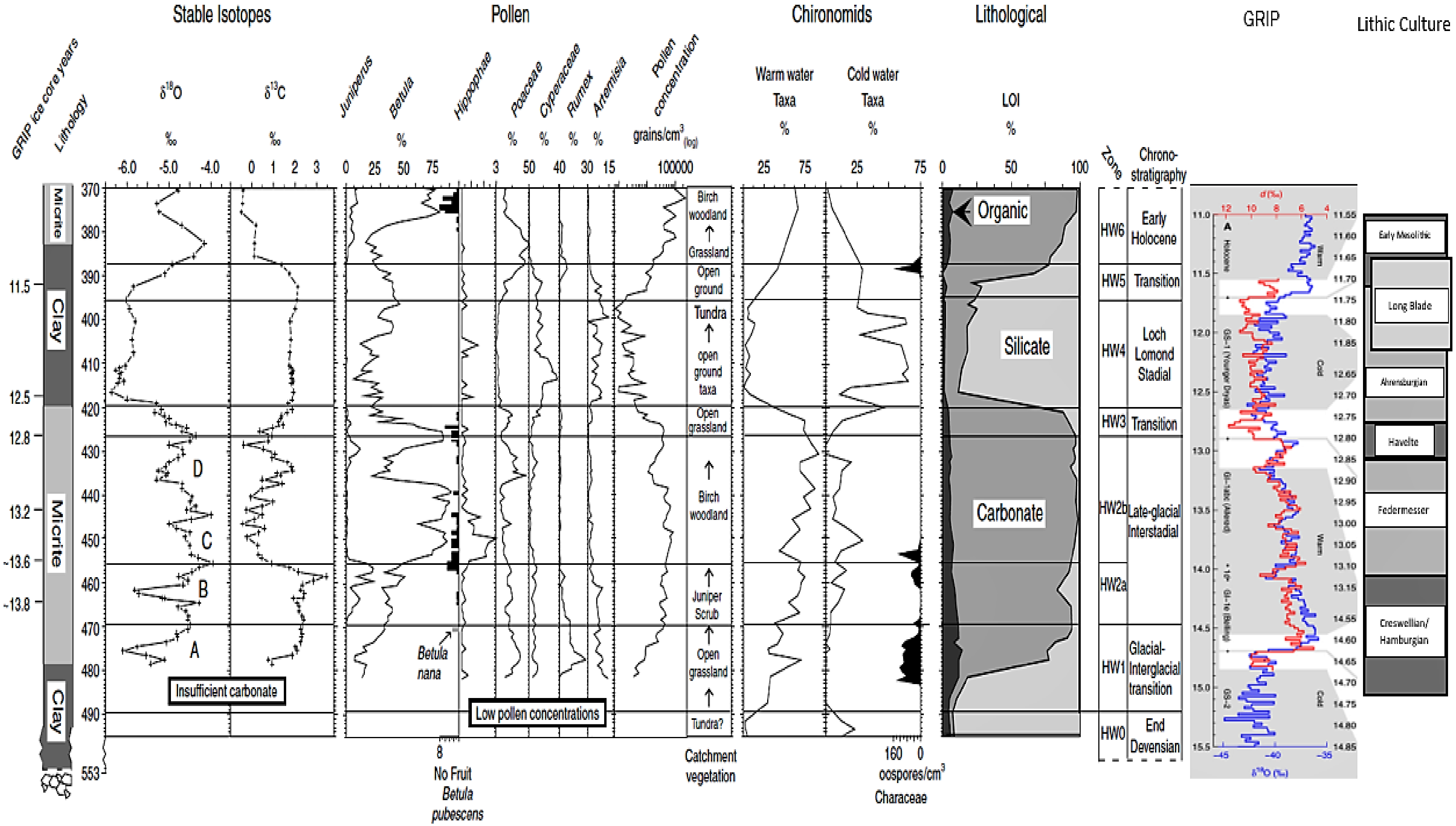
Chapter 1: Climate and Environment

1.1 - Introduction

This chapter provides a climatic and environmental background for this study to allow the comparison of dated human occupations to dated climatic and environmental events. Assigning climatic and environmental events to specific dates is fraught with difficulties as will be seen, but nevertheless these comparisons currently give us the closest estimates of the conditions that would have been experienced by prehistoric hunter-gatherer populations.

This study looks specifically at the time period from 14,000 to 10,000 cal BP and encompasses several climatic events. These are, in order, the Allerød interstadial, the YD stadial, and the Preboreal. The Allerød interstadial (ca. 14,000-13,000 cal BP) and YD stadial (12,900-11,700 cal BP) are associated with the Pleistocene epoch while the Preboreal chronozone (ca. 11,700-10,000 cal BP) is associated with the Holocene epoch.

The extensive and well documented climatic data for the northwest region (see Fig 1.1 for an overview) will be presented first, followed by a description of climate changes in the southwest of Europe.



(Fig 1.1: Multi-proxy record of northwest U.K. after Jones et al. (2002), the GRIP and NGRIP ice core record modified after Steffensen et al. (2008), and estimated stone tool cultural grouping timescales, representative of the general climate and environment across the northwest European study region)

1.2 - Climate and Environment in Northwest Europe

1.2a - The Allerød Interstadial (ca. 14,000-12,900 cal BP)

The Allerød interstadial follows the short lived stadial event known as Dryas II which occurred between the Bølling and Allerød Interstadials. At the onset of this period conditions in northwest Europe become rapidly warmer (although not as warm as the previous Bølling interstadial). The Allerød interstadial consists of three phases:

1. An initial wet and warm phase

2. A sharp colder and drier phase

3. A final wetter and warmer phase

In regards to temperature, research by Brooks and Birks (2000; 2001) found that the chironomid data from Whitrig Bog, southeast Scotland, show Allerød mean July air temperatures peaking around 12°C, correlating well with the known flora in this region. The mean July temperatures in northern England are thought to have reached around 11°C-13°C with temperatures increasing towards the end of the Late Glacial (Walker et al., 1993). This is also reflected by the environmental data collected at St Bees, Cumbria, northwest U.K. (Coope and Joachim, 1980), and Glanllynnau in North Wales (Coope and Brophy, 1972). Evidence from the analysis of chironomid data from five sites in the northwest of England (Hawes Water, Little Hawes Water, Urswick Tarn, Cunswick Tarn and Sunbiggin Tarn) suggest average Allerød temperatures of between 12°C-3°C (Lang et al., 2010; Bedford et al., 2004) and in southern England, pollen data from Sea Mere, Norfolk, southeast England, indicates southern England and Wales were slightly warmer than northern England with average summer temperatures of around 13°C (Isarin and Bohncke, 1999; Walker et al., 2003). However, beetle evidence suggest that summer temperatures began to cool from ca. 13,300 cal BP (Atkinson et al., 1987), which is also seen in the study by Bedford et al. (2004) who found temperatures in fact declined slowly towards the end of the Allerød to a minimum of approximately 11.4°C but with a short rise in temperature of around 1.5°C just before the rapid decline into the YD. This short upturn can be clearly seen in the pollen diagrams of this region with evidence of a short-lived expansion of birch woodland just before the YD stadial (Walker et al., 1993; 2003; Innes et al., 2009).

Regional pollen diagrams also indicate a distinct cold fluctuation at the end of the Lateglacial in the U. K., prior to this short warming period, which was accompanied by a contraction in birch woodland and an increase in juniper and open ground taxa (Walker et al., 1993; Innes et al., 2009). This cold climatic fluctuation is dated to around 13,100 cal BP at Llanilid, South Wales, where there is evidence that temperatures dropped by 4^{o}C-5^{o}C (Walker et al., 1993).

The northern French beetle evidence at Conty suggests that the climate throughout most of the Allerød in the Somme Valley was much like todays with many species still present in the modern-day assemblages. However, some species of cold climate adapted beetles inhabit more northerly latitudes. These species are adapted to colder climates than modern day northern France which suggests the Allerød in the Conty region was slightly colder than the present day (Ponel et al., 2005). From this, Ponel et al., (2005) estimate mean July temperatures were close to 16^{o}C and mean January/February temperatures between 0^{o}C and -5^{o}C. However, malacofauna data from Conty in the Somme Valley, also show during the second half of the Allerød, between 13,529 ± 145 cal BP and 13,313 ± 158 cal BP, there is a clear decline in species richness and diversity in the malacofauna suggesting increasing dryness and a shift to less favourable conditions (Limondin-Lozouet and Antoine, 2001). This drier phase is also seen by the pollen study of northern France by Ponel et al. (2005).

In the Netherlands, the Allerød mean July temperatures were between 13^{o}C-16^{o}C based on coleoptera faunal remains, and at least 14^{o}C based on floral remains. Chironomid-inferred mean July temperatures of ca. 16.0°C-16.5°C during most of the Allerød at Hijkermeer, northwest Netherlands (Heiri, 2007), also fall within this range. Coleoptera data indicate that average winter temperatures were between -16^{o}C and +6^{o}C. At the end of the Allerød, around 13,200 cal BP, as with the U.K. evidence, there is again evidence for a climatic fluctuation with a decline in mean July temperatures. January temperatures were considered to have dropped to between -13^{o}C and -16^{o}C, with the lower range inferred from coleoptera data. With the summer temperatures largely unchanged these temperature conditions would allow for deep seasonal frost and a more intensive action of the freeze-thaw cycle (Hoek and Bohncke, 2002; Hoek et al., 1999). This cold phase is also supported in the Belgian evidence where the faunal analysis by Cordy (1991) found that there was a small peak of cold adapted species (especially Norway lemmings) evident during this period (Cordy, 1991).

There is clear evidence that the Allerød was a general warming phase, but how did this effect the environment? At the onset of the Allerød there was an increase in forest cover, with an open birch/juniper woodland developing in the more northerly regions of the study area, such as Scotland (Brooks et al., 1997), and the replacement of the replacement of juniper scrubland with birch woodland across most of England and Wales ca. 14,000-13,700 cal BP (Walker et al., 1993). Evidence suggests that the maximum expansion of birch woodland occurred around 13,400 cal BP in northern England (Innes et al., 2009), but there is evidence of a north-south gradient in birch pollen percentages suggesting there was a higher cover of birch the further one travels south (Innes et al., 2009). This general pattern of expansion of birch woodland (but with the addition pine) and a decline in herbs and shrubs is also seen in northern France (Ponel et al. (2005), the Netherlands (Hoek, 1997; Hoek and Bohncke, 2002), Belgium (Cordy, 1991), and northern Germany (Terberger, 2006a). However, in the Netherlands, there is evidence of a later expansion of pine and a decline in herbs and shrubs such as salix and juniper that indicates a colder, drier phase (Van Geel et al, 1989), and by 13,200 cal BP pine dominates the vegetation, but by 13,000 cal BP wetter conditions meant that the pine forests could not be sustained and died back. Many of the dead pine were prone to forest fires and burnt down, which is the reason why the Usselo soil of Allerød age frequently contains charcoal particles (Hoek and Bohncke, 2002). This is supported by Van Geel et al. (1989) who found there was a sharp decline in pine and a rise in birch pollen during the transitional phase of the Allerød/YD transition.

Lake level activity in the Netherlands during this period, from 14,000-13,200 cal BP, were high (except for a short period around 13,500 cal BP) which is thought to have caused birch to return to the region. However, interestingly, there is evidence from the Dutch lake data from 13,200-13,000 cal BP, that there is a low in lake levels, which sometimes led to hiatuses in the sedimentary sequence (Hoek and Bohncke, 2002). This low in lake levels corresponds well with the sharp downturn seen towards the end of the Allerød both in the U.K. and the Netherlands around the same time ca. 13,100 cal BP.

Allerød Summary

It is clear that, over much of the north-western European region, the Allerød is a phase of warming and establishment of trees, mainly birch in the U.K. and birch and pine in mainland Europe. Temperatures are estimated to be between 13°C-16°C with evidence of a general north-south gradient. However, this period should not simply be regarded as a homogenous warm interstadial (as also noted by Pettitt and White (2012). There are some studies suggesting there was a gradual cooling from the start of the Allerød to the beginning of the YD (Atkinson et al., 1987). There are also two fluctuations seen in some records; firstly, a significant drop in temperature by as much as 4°C-5°C ca. 13,100 cal BP; secondly, a brief, but significant, warm stage just before the beginning of the YD between ca. 13,000-12,900 cal BP.

The general readvance of trees and forest would have no doubt forced a change in hunter-gatherer settlement and subsistence organisation, with new species becoming available in a less open environment. However, the evidence for colder and drier fluctuations might be important, especially in terms of this study, as human populations may have briefly adapted their mobility strategies to these conditions within a commonly generalised warming phase.

1.2b - The Younger Dryas Stadial (ca. 12,900-11,700 cal BP)

The YD is a stadial event that occurred ca. 12,900-11,700 cal BP over much of the northern hemisphere. Temperatures dropped drastically with the onset of YD and in northwest Europe where there was a re-advancement of glacial ice sheets over much of Scotland and Scandinavia. There have been several theories put forward to explain the trigger for the YD stadial, with no clear cause identified. These theories go outside the scope of this study and will not be discussed here.

Brooks and Birks (2000; 2001) chironomid data show mean July temperatures in southeast Scotland drastically decreased by at least 4^{o}C-5^{o}C at the YD onset, stabilising at about 7^{o}C-8^{o}C. This corresponds well with the pollen data for this region at this time. However, these temperatures are not as cold as those inferred from the degree of glacial readvance that is known to have occurred in Scotland (Brooks and Birks, 2001), which would point to temperatures being 2^{o}C-4^{o}C lower than those suggested by the coleoptera evidence (Brooks and Birks, 2000; Brooks, 2006). There is also evidence there may have been a slight increase in average temperature by 1^{o}C in the second-half of the YD (Brooks and Birks, 2001).

In northern England and Wales, mean July temperatures were between were 9^{o}C-11^{o}C and winter temperatures were as low as -15^{o}C to -20^{o}C (Walker et al., 1993; 1994; Coope and Joachim, 1980; Atkinson et al., 1987). This shows around a 1^{o}C-2^{o}C increase in mean July temperatures from those at Whitrig Bog, Scotland, for the same period. Both Bedford et al.

(2004) and Lang et al. (2010) show that temperatures fluctuated through time in the U.K during this period. At the onset of the YD, July temperatures dropped by about 4°C, reaching between 8°C-9°C, later rising by about 1°C to values of around 9°C-10°C, with a final fall in temperature just before the rapid rise at the beginning of the Holocene. In southern England and Wales, there is evidence temperatures were slightly warmer with mean July temperatures of around 10°C-11°C (Walker et al., 2003; Hunt and Birks, 1982). However, Walker et al. (1994) and Isarin et al. (1998) also find strong evidence suggesting a subdivision of the YD, of an earlier cold and wet phase by a relatively warmer and drier phase.

The temperatures of southern England and Wales are similar to those of northern France (Gandouin et al,. 2007; Limondin-Lozouet and Antoine, 2001) and Belgium (Isarin and Bohncke, 1999), with chironomid data from St-Momelin in the Omer Basin, France, suggesting YD mean July temperatures ranging from 9°C-11°C in this region (Gandouin et al., 2007). The subdivision of two phases can also be seen at St-Momelin (Gandouin, 2007) and at Conty (Limondin-Lozouet and Antoine, 2001). Chironomid assemblage's characteristic of "lotic phases" seem to correspond to precipitation increases, while "lentic phases" correspond to precipitation decreases. The results from St-Momelin show a good correlation with the climatic subdivisions of the YD with the first phase showing a maximum of lotic taxa, and the second phase showing a distinct rise in the lentic taxa (Gandouin, 2007). At Conty, malacofauna species diversity decreases rapidly at the onset of the YD and the environment appeared to have been colonised by aquatic taxa typical of stagnant habitats. There is also evidence for a reduction of vegetation cover and a renewed fluvial activity. In the second-half, aquatic taxa decline while hygrophile cold-tolerant species increase, indicating a development of vegetation under slightly more stable and drier conditions (Limondin-Lozouet and Antoine, 2001). Temperatures were also similar in the Netherlands with mean July temperatures between 10°C-11°C (Bohncke, 1993; Hoek and Bohncke, 2002), and from coleoptera evidence mean January temperatures dropped from between -16°C and +6°C to between -15°C and -7°C (Hoek and Bohncke, 2002). This brought a decline in the mean annual temperature to below -1°C (probably between -2°C and -5°C), and allowed the development of a discontinuous permafroast, which is supported by fossil periglacial phenomena (Bohncke, 1993; Hoek and Bohncke, 2002). These temperatures lasted to ca. 12,700 cal BP where the mean annual temperature rose above -1°C and discontinuous permafrost conditions were terminated and mean July temperatures rose to between 13^{o}C-15^{o}C. However, in the absence of snow cover, conditions may still have been very severe for plant life (Hoek and Bohncke, 2002). There are slightly higher chironomid-inferred mean July temperatures of ca 13°C-14°C during the YD at Hijkermeer, northwest Netherlands (Heiri, 2007), and these temperatures are more in line with those proposed for the second-half of the YD than the first-half, and may be supported by analysis of macrofossils at Borchert that found, during the latter part of the YD, the presence of certain herbaceous forms such as Typha *latifolia*, indicate a minimum average July temperature of 12-13°C (Van Geel et al., 1981). Palynological records from the Netherlands again support the YD subdivision (i.e. an initial cold, wet phase followed by a warmer, drier phase) with an increase of steppe and halophytic species, such as Artemisia, evident during the latter half of the YD (Walker et al. 1994).

This abrupt drop in temperature caused a significant change in the environment with a clear decrease in scrub taxa and an increase in herb taxa in Scotland, with evidence of tundra-like conditions and a decrease in warm-water taxa and an increase in cold-water taxa (Brooks et al., 1997). In northern England, birch woodland was replaced by a predominantly herbaceous flora with an arctic/alpine steppe. However, there is some evidence birch persisted into this period with birch macrofossils found at Skipsea Withow Mere, dating to the first-half of the YD (Walker et al., 1993). The evidence strongly suggests, in northern England, there was a largely open steppe or steppe-tundra landscape, with localised discontinuous permafrost characterised by cold, desiccating easterly winds (Walker et al., 1993; 1994; Lang et al., 2010). In southern England and Wales there is evidence of a more scrub tundra, with a mixture of birch, salix and a range of open-habitat taxa becoming established locally (Walker et al., 2003; Hunt and Birks, 1982). Like the Allerød, this general pattern of landscape-opening is also seen in northern France (Ponel et al., 2005), the Netherlands (Van Geel et al., 1989: Hoek, 1997: Hoek and Bohncke, 2002), Belgium (Cordy, 1991), and Germany (Terberger, 2004). However, there appears to be a slight difference in the reaction of vegetation in Belgium, which appears to have resisted the cold rather well, and an open birch and pine forest where an herbaceous undergrowth appeared (Cordy, 1991), compared to scrub and tundra steppes in the UK and the Netherlands. This may suggest that some areas in Belgium were protected from the cold of the YD and possibly represent an environmental enclave in this region. Cordy (1991) suggests the environment is mainly open, but probably less homogeneous possibly indicating a mosaic of distinct landscapes. Palaeohydrological and palynological data from Belgium again strongly echo the YD subdivision of an initial cold, wet phase followed by a warmer, drier phase (Walker et al., 1994).

The Dutch evidence also finds that the YD transition saw a sudden rise in lake levels from the lowered levels at the end of the Allerød (Hoek and Bohncke, 2002). Lake levels again dropped at around 12,700 cal BP when species growing in the border zone of the lakes start to increase, most notably mosses that grow in shallow water, start to appear and increases in aeolian activity also point to drier conditions (Hoek and Bohncke, 2002). Palaeohydrological data from the Netherlands indicate the later part of the YD was significantly more arid than the earlier period prior to ca. 12, 500 cal BP, shown by evidence from Germany where Terberger (2004) found the maximum openness in Vorpommern is found at the end of the YD, which might be the result of a drought.

<u>Summary</u>

There is clear evidence of an abrupt climatic deterioration at the onset of the YD which is universally seen in the northwest European record. There is a significant reduction in tree cover and evidence for the opening of the landscape leaving an environment resembling an "arctic tundra" over large parts of northwest Europe. Several studies indicate that some warmer climate trees such as birch persist into this period suggesting, at least in specific enclaves, the YD may not be as severe as the climate records imply. This event, like the Allerød, was not a homogeneous climatic phase, but characterised by two distinct episodes. Within the literature there is strong evidence of a general pattern of two phases within the YD (Isarin and Bohncke, 1999; Limondin-Lozouet and Antoine, 2001; Gandouin, 2007; Hoek and Bohncke, 2002):

1. An initial cold, wet phase (ca. 12,900-12,500 cal BP)

2. A warmer, drier phase (ca. 12,500-11,800 cal BP).

Hoek and Bohncke (2002) and Terberger (2004) found, in the Netherlands and northern Germany respectively, the YD transition saw a sudden rise in lake-levels from the lowered levels at the end of the Allerød. This wet period coincides with a drop in temperature occurring around 12,700 cal BP, while palaeohydrological data from the Netherlands indicate that the later part of the YD was significantly more arid than the earlier period prior to ca. 12,500 cal BP, with a clear increase in steppe and halophytic species (Walker et al. 1994). The maximum openness of the YD is recorded towards the end of this period in northern Germany which Terberger (2004) believes may be the result of drought conditions. He also notes there is a clear north-south gradient in temperatures in northern Germany probably as a consequence of the Scandinavian Ice Sheet. This caused colder conditions in more northerly areas and warmer temperatures in more southerly areas. However, the UK does not show such a clear division, but there is a warming pattern of about 1°C through the YD (Lang et al., 2010).

The dramatic onset of colder semi-glacial conditions, with the presence of open steppe-tundra, and the re-appearance of cold adapted ungulates (notably reindeer and horse) in many regions of northwest Europe (Drucker et al., 2016; Bignon and Eisenmann, 2002) would have no doubt had a major effect on human hunter-gatherer populations. These particularly harsh conditions lasted until the mid-YD where there is a general consensus that conditions improved slightly during the second half of the YD. However, the initial phase, although cold, was wet with evidence for high lake-levels, while the second-half was warmer and drier with significant decreases in lake-levels. It is thought here that the wet conditions would have sustained human populations during the onset of this abrupt change, and not forced a retreat from more northerly regions, and this is argued from my previous unpublished MPhil thesis (Andrews, 2012), which found there to be no significant reduction in the number of C^{14} dates from the late Allerød into the early YD, while there was a distinct decrease in the number of C^{14} dates during the latter half of the YD. There was also evidence for lower numbers of C^{14} dates during the drier phases of the Allerød and PB, suggesting drier phases had a bigger impact on human behaviour rather than temperature. Unfortunately, as we will see, the lithic assemblage sample size for the first-half of the YD is too low and thus no reliable comparisons can be made between the first and second halves of this period, and the YD will have to be treated as a single cold phase for the purposes of this study.

1.2c - The Preboreal Chronozone (ca. 11,700-10,000 cal BP)

In most parts of northwest and central Europe the transition to the Holocene sees a change from open vegetation to a dense forest. This change seems directly related to the rising temperatures which started ca. 11,560 cal BP and was possibly in the order of more than 5°C within less than 80 years (Usinger, 2004), with beetle evidence in the U.K. suggesting temperature rates increasing by possibly as high as 2.8°C per century (Atkinson et al., 1987).

The chironomid data from the northern England suggests an increase in mean July temperatures from the previous YD in the order of 5°C to between 13°C-14°C, and this amelioration is further pronounced in southern England, where evidence from South Wales indicate there was a marked increase in temperature in the order of 9°C-19°C ca. 11,400 cal BP (Walker et al, 2003; Hunt and Birks, 1982). However, there is also evidence for an interruption in this climatic upturn with a cold oscillation (possibly the "Preboreal Oscillation" or "PBO") in the early Holocene where mean July temperatures dropped by up to 1°C (Lang et al., 2010; Bedford et al., 2004).

This warming is also clearly seen in northern France, with estimated average temperatures at least 1°C-2°C higher than 12°C-14°C predicted from nearby sites in the more northern U.K. and Norway (Gandouin, 2007; Brooks and Birks, 2000; Bedford et al., 2004). This is supported by Zagwijn's (1994) study of indicator species in pollen records in northwest Europe from ca. 11,500 to 11,000 cal BP that show that January and July temperatures can be estimated to be around 12°C-16°C respectively for this period in this region. At the onset of the Holocene at Conty, the malacofauna show a higher diversity, suggesting a climatic improvement, and the composition of the fauna seem to dramatically change with many of the species that became extinct during the Bølling Interstadial returning to the region (Limondin-Lozouet and Antoine, 2001).

Importantly there is a persistence of cold-water adapted taxa at sites such as St-Momelin. This may well be due to climatic instability from events such as the PBO, witnessed from many sites across northwest Europe from ca. 11,300-11,150 cal BP (Gandouin, 2007). However, it may also be due to relatively cool temperatures during the spring induced by cold winters (Gandouin, 2007), supported by Davis et al. (2003) whose Holocene climate reconstruction of northwest Europe shows that, from pollen data, winter temperatures were as low as -9°C in this area during the early Holocene, while the summer temperatures were already close to those of the present day. In the Netherlands, mean July temperatures were again likely restored to those of the previous Allerød values of between ca. 15°C-17°C (Hoek and Bohncke, 2002; Van der Plicht et al., 2004), and is supported by the chironomid-inferred temperatures of 15.5°C-16.0°C during the early Holocene at Hijkermeer, northwest Netherlands (Heiri, 2007).

In Scotland and northern England and Wales, the environmental evidence suggests a clear amelioration in the climate associated with the Early Holocene with significant increase in birch/juniper and Empetrum (an evergreen shrub) at the expense of herbaceous taxa and evidence of marl (Brooks et al., 1997). This pattern is clearly seen in the vegetation records of France (Gandouin, 2007), the Netherlands (Hoek and Bohncke, 2002; Van der Plicht et al., 2004), Belgium (Crombé and Verbruggen, 2002; Crombé et al., 2011), and Germany (Terberger, 2004). In Germany, there is evidence that the closing of the landscape was rapid and probably took no more than 30-80 years (Klerk, 2004).

Also, in the Netherlands from ca. 11,800 cal BP, there was a return to higher lake-levels indicated by the increase in aquatic taxa and a decline in telmatic (bog and peat swamp) taxa. There was also a spread of both birch and herbaceous plants suggesting a spread of wet localities. This is interrupted by a short-lived phase from 11,300-11,100 cal BP, where there is a sudden decrease in lake-levels, and mosses again appeared around the lake edges. The subsequent phase after 11,100 cal BP sees an increase in lake-levels and aquatic taxa, and marks the termination of this dry interval (Hoek and Bohncke, 2002). The Dutch botanical evidence also sees these fluctuations within the PB, indicating, from 11,800-11,100 cal BP, after an initial spread of birch at the beginning of the PB, there is evidence for a short, drier, period where there is a decrease in birch and an increase in steppe-like vegetation, rich in grasses around the Rammelbeek phase, ca. 11,300-11,100 cal BP (Hoek, 1997; Hoek and Bohncke, 2002; Van der Plicht et al., 2004). This data corresponds strongly with the reported drop in lake-levels.

However, in northeast Germany, there is evidence the initial amelioration at the beginning of the PB caused a dramatic lowering of the groundwater levels, affecting the availability of water as shallow basins and lakes became desiccated, but this was quickly followed by a gradual rise of groundwater levels, in which valley basins became moist again (Klerk, 2004).

PB climatic variability is also seen by Van der Plicht (2004) who found that, at Borchert, following the YD/PB transition, two climatic shifts could be inferred. Around 11,400 cal BP the expansion of birch forest was interrupted by a dry continental phase, which was dominated by open grassland vegetation and can be ascribed to the PBO, as observed in the GRIP ice core. At 11,250 cal BP there is evidence of another sudden shift to a more humid climate. This second change appears to be related to:

1. A sharp increase of atmospheric ^{14}C
2. A temporary decline of atmospheric CO^2
3. An increase in the GRIP 10Be flux.

Van der Plicht et al. (2004) suggest this points to a decline in solar activity, which may have caused the changes in climate and vegetation at around 11,250 cal BP. Based on changes in the AP/NAP ratio and the dominant arboreal taxa at Borchert, they further subdivided the PB into three phases; a Friesland Phase, a Rammelbeek Phase and the Late Preboreal.

- The Friesland Phase is characterised by a strong rise in the values of birch and was a period of rising mean summer temperatures (Van Geel et al., 1981).
- The Rammelbeek Phase saw an interruption in the expansion of the forest and grasses such as Poaceae dominated the regional vegetation. Thermophilous plants, such as lily and Ceratophyllum suggest that dry conditions prevailed during this phase with relatively warm summers with mean July temperatures around 13°C-15°C (Van Geel et al., 1981), although the winter temperatures may have been low (Van Geel and Kolstrup, 1978; Van Geel et al., 1981).
- During the Late PB, birch forest expanded again and the macrofossil record shows that birch occurred in the regional vegetation (Van Geel et al., 1981). The local presence of Sphagnum moss suggests relatively oligotrophic conditions (conditions lacking in nutrients) and a rainwater-fed local vegetation. There is also an immigration of Pine during the latter part of the Late PB phase (Van der Plicht et al., 2004).

These PB climatic fluctuations are also seen in several pollen diagrams in northern Germany, which clearly show the PB warming was interrupted by a climatic setback, widely known as the PBO. These diagrams show a dramatic decrease in birch pollen, suggesting a return to a more open scrub or tundra similar to that of the YD. This drop in pollen may be linked to a drought caused by the lowering of the water table by river incision (Usinger, 2004). However, the timing and exact characteristics of this event vary significantly from one record to the next. Some show evidence for a clear decrease in temperature of around 3-4°C with no changes in lake-levels in the early stages, while others show relatively warm conditions with drought around the mid-PB. This has led to the interpretation that there are actually two separate PBO events (PBO1 and PBO2).

- PBO1 is an early PB event reflecting a decrease in temperature
- PBO2 is an event which occurred in the middle PB and reflects an apparently drier climate, possibly caused by increasing temperatures.

Pollen diagrams from Kubitzbergmoor clearly show two separate birch minima, the first at the beginning, and the second in the middle of the PB (Usinger, 2004). The first event can be explained by decreasing temperatures, while the second may have been caused by lower water levels, as implied by the maximum of green algae around this time. Similar patterns can be seen in high-resolution diagrams from Uteringsveen-2, Stokersdobbe, Plussee and Kreutzee (Usinger, 2004). However, at several sites in northern Germany, and further north in Denmark at the site Herthamoor, there are no indications of the climatic setback of the PBO (Terberger, T., 2006b).

Summary

With the onset of the PB, there is a significant reversal in the climate with a rapid re-establishment of birch and pine forests, and a return to temperatures similar to that of the Allerød, and in some regions to that of today. However, it seems clear that the PB was a period of climatic instability, with several upturns and downturns. Many palaeoclimatologists and archaeologists recognise at least one major downturn, the PBO. During this event there is a decrease in tree cover and an opening of the landscape. The records from the lowlands also show a decrease in lake-levels during this period. The exact timing of this event has been difficult to resolve and is a contentious issue. Several experts believe that this difficulty stems from the fact that there is more than one climatic fluctuation during this period, which distorts the exact timing of the PBO. Van der Plicht et al. (2004) recognises at least three distinct phases: a Friesland Phase, a Rammelbeek Phase, and the Late Preboreal, while Usinger (2004) further provides evidence of the instability of the PB, suggesting that there may have been two PBO events (PBO1 and PBO2).

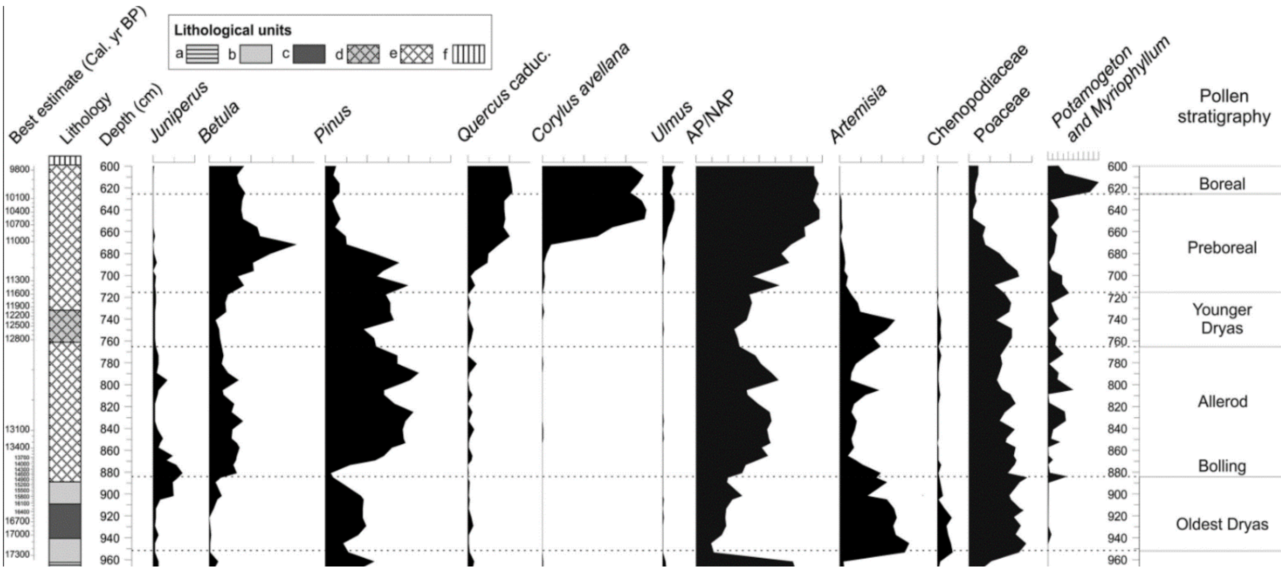
It is important to note that the PBO is not recognised in every environmental study as seen by the pollen diagrams from Endingen in northern Vorpommern, which show no evidence for a cold, open phase during the PB (Terberger, 2004). This may further the argument that environmental reactions to climatic events can also be highly dependent on a number of non-climatic variables, most likely related to local landscape/geographical features.

The rapid amelioration in the climate would have been easily noticeable to hunter-gatherer populations, with some studies theorising significant temperature rises and closing of the landscape within 30-80 years, thus only a few human generations. One would assume that this dramatic climate reversal would have had a distinct effect on how human populations behaved and interacted with this new environment. The closing of the landscape along with the introduction of new animal species would have significantly altered the way in which they hunted game.

It also seems clear, from the current evidence, that the PB was a period of high instability in both the climate and environment throughout northwest Europe. This would no doubt have had a significant effect on the development of hunter-gatherer strategies. It is interesting to note that the Long Blade (or Bruised Blade) industries in northwest Europe span (from current C^{14} dated evidence) the length of the dry phase of the YD and well into the PB (from ca. 12,500 cal BP-10,000 cal BP) while the Ahrensburgian industries span the entire YD and into the Early PB, seemingly unchanged (Lewis and Rackham, 2011; Froom, 2005; Jacquier, 2014; Mithen et al., 2015; Deeben and Schreurs, 2012). This may imply that the PB, which is generally thought of and characterised as a period of climatic amelioration, may have in fact been as, if not more, unpredictable for hunter-gatherer populations to live in, in terms of availability of water, animals, and vegetation. It is therefore possible to further imply that hunter-gatherer populations, faced with this climate instability in the PB, did not change their lithic technology from the preceding YD as there was no extended period of climatic stability until the latter stages of the Late PB in which changing technology would have been a more efficient strategy.

1.3 - Synthesis of the Southwest European Climate and Environment

The environmental response in south Europe generally seems to have been remarkably similar to the northwest, (see Fig 1.2), but notably more subdued in terms of temperature. The number of climatic and environmental reconstructions are more limited when compared to the northwest European region, so a much shorter synthesis of the observed conditions will be presented here.



(Fig 1.2: Pollen diagrams from Aubrac, southern Massif Central, representative of the general environmental response in southern Europe, modified after Gandouin et al., (2016))

The Allerød

During the Allerød there was a significant climatic warming that promoted the growth of an open forest scrub (Barbaza, 2011), with arboreal pollen (AP) percentages ranging from 30-50% not uncommon, and there is evidence for climate variability, with a colder phase roughly halfway through the Allerød (Straus, 1991). Lake-levels during this period were high and the upper limit of woodland was around 1600 masl in areas such as northern Spain (Sobrinoa et al., 2013). From the diatom and pollen spectra from northern Spain and Pyrenees, there is a trend of increasing humidity through the Allerød in the south, but colder, drier phases have been identified, where there is evidence for a cooling phase and drying of the lakes around 13,200-12,900 cal BP, and a final warming phase with a recovery of lake-levels just before the YD stadial (Vegas-Vilarrúbia et al, 2013), much like that seen in the northwest European data.

The Younger Dryas

With the onset of the YD there was a sharp decline in the percentages of arboreal pollen (AP< 20% in both coastal and mountain areas) and a return to more open prairies with shrubs, indicating both a colder climate, and a more open environment with AP percentages of 10-20% common during this period (Straus, 1991; 2011). However, the continuation of oak in the western Pyrenees indicates that this species was not affected by the YD (Barbaza, 2011) and shows that conditions were not as harsh as those in the northwest. Temperatures during the YD were definitely colder, as seen in the Apennines, northern Italy, where temperatures were 5.6-9.7 °C below the modern average, compared to less than 4.8 °C below the modern average during the Holocene. During this phase, arctic birds, including arctic marine birds, point to sea temperatures considerably colder than today, even in southern Italy (Mussi and Peresani, 2011). The first part of the YD (ca. 12,850-12,435 cal BP), was notably drier and cooler, leading to low lake-levels, and a marked reduction in woodland, while during the second part (ca. 12,435-11,875 cal BP) the climate was still drier with a further opening of tree, shrub and herb vegetation (Sobrinoa et al., 2013; Vegas-Vilarrúbia et al, 2013). However, one cannot assume the environmental response was uniform across the south region. It is apparent there were distinct regional differences in southern Europe during the YD, which appears to have been briefer and less intense in Iberia than in southern France, which suggests that there were distinct regional differences in the environment (Jones, 2016). In Spain, vegetation reconstructions suggest there were differences between the lower elevation centre and the higher elevation north of Iberia, while the Euro-Siberian region seems to have been more effected by the YD than the Mediterranean region, where there is evidence that more temperate vegetation may have concentrated in glacial periods (Stevens et al., 2014; Aura et al. 2011; Jones, 2016; Tarroso, 2008; Dupré, 1988; Iriarte, 2008). The temperate and arid climate of Mediterranean Spain suggests that there was climatic continuity from the Allerød through to the YD and the effects of the YD were mild and relatively gradual, due to both the latitude and the influence of the Mediterranean Sea. Straus (2011) also highlights that in the oceanic regions there is an extremely complex mountain geography where there were local mountain refugia for a number of temperate taxa. While Uzquiano (1992) has shown that the interior mountain valleys continued as an arboreal refugia.

The Preboreal

Like the northwest there is a distinct return of tree species at the onset of the PB which recovered rapidly at the close of the YD. The transition to PB conditions was abrupt and marked, with AP percentages often increasing to 50% or more, and warmer tree and shrub taxa become fairly abundant and varied during this period (Straus, 1991; Straus, 2011). After the YD (ca. 11,875-11,630 cal BP) the lake-levels rose and herb and shrub vegetation expanded. A strong development of woodland occurred around 11,630-11,490 cal BP, which was associated with warmer and moister climatic conditions. The regional tree expansion stopped during the PBO (ca. 11,490-11,050 cal BP), when lower lake-levels existed in the Sierra da Estela uplands in northern Spain. By the end of the PB, open woodland was gradually replaced by *Quercus* forest up to 1730 masl (Sobrinoa et al., 2013). This indicates evidence of a similar disruption of warming during the PB as in northwest Europe, although there seems to be limited evidence of the high level of variability seen in the northwest climatic records.

These general patterns are also seen in northern Italy and again, the brief climatic downturns during the Allerød and the PB are evidenced in several regions (Magny et al., 2006). The wetter intra-Allerød cooling, and the first-half of the YD, is evidenced by wetter conditions, but again we see the trend of a dry and cold period during the second-half of the YD. There is also evidence for low lake-levels in the early stages of the PB, similar to that seen in the northwest data, followed by a rapid increase in lake-levels into the later stages of this period (Magny et al., 2006). In the higher altitude of the Alps and Pre-Alps, pollen evidence suggests there was a distinct growth of deciduous tree species, such as oak and hazel, and an increase in the maximum treeline during the warming of the Allerød, followed by a reduction in these species with an associated reduction in the treeline with the onset of the YD, and an increase in pine and birch, and an increase in steppe and meadow species. At the onset of the PB there is a rapid increase in warm climate species, such as oak and elm, the formation of more closed forests, and evidence of the upward migration of the treeline (Joannin et al., 2013).

1.4 - Conclusion

Overall there seems to be a high level in continuity in the north-western study region with a generalised pattern of:

1. A warm period during the Allerød with an expansion of forest.

2. A significant deterioration in climate during the YD with lower temperatures, and an opening of the landscape.
3. A rapid amelioration in climate during the PB back to warmer temperatures and establishment of forest, and an increase in the diversity of flora and fauna.

However, Atkinson et al. (1987) find that both summer and winter temperatures were rarely stable for more than a century or two throughout the period of this study, and were more often constantly changing. It is evident there are several fluctuations in both climate and environment within these climatic phases, which is crucial to recognise when inferring hunter-gatherer behaviour related to these generalised patterns. These fluctuations include, most notably:

1. A cold and drier phase towards the end of the Allerød (ca. 13,200 cal BP) in which there was a brief opening of the landscape and lake-levels decreased.
2. A final warm and wet phase at the terminal Allerød, just before the YD climatic decline, where lake-levels increased from the previous brief cold and dry phase.
3. An initial cold and wet phase in the first-half of the YD (ca. 12,900-12,500 cal BP) where lake-levels continued to be high.
4. A warmer, but drier, second phase of the YD (ca. 12500-11,800 cal BP) where lake-levels decreased.
5. A drier and possibly cooler phase during the PB (ca. 11,300 cal BP) in which lake-levels dropped and the landscape opened slightly. This is probably related to the so called PBO event.

Recognising these fluctuations brings about two important questions when attempting to ascertain human reactions to major climatic events:

1. Are the very brief climatic reversals seen in the Allerød and PB significant and long enough to change hunter-gatherer behaviour, and if so would this be noticeable in the archaeological record during these periods?
2. To what degree would hunter-gatherers respond to the two different phases recognised during the YD?

As the brief reversals during the Allerød and YD are in the order of 100 to 200 years long, it is impossible to reliably attribute assemblages to these phases with the current resolution of dating techniques. As there was no information found about any possible changes in the larger faunal species during these phases, it is assumed these brief changes in climatic conditions were not long enough to bring about a significant change in large animal populations/behaviour. As such, one could infer hunter-gatherer populations would not have had to change their strategies drastically during these periods. Also, due to the fact that these periods were very brief, it is unlikely that a significant amount of the assemblages collected for this study would date to these periods, and thus would not significantly affect the general results. This is definitely the case for the Inter-Allerød cold period, which is particularly brief (in the order of less than 100 years). However, the PB appears to be more complex, which might affect how hunter-gatherers changed their behaviours after the harsher climates of the YD. There appear to be very varied climatic signals recorded for the PB, with some reporting environmental changes associated with the PBO as being cold and dry, others warm and dry, while some do not report any notable climatic changes at all. Others split the PBO into two separated events, with the first a cold phase, and the second a drier phase. The PBO was also longer than the Allerød cold event (possibly as much as 200 years long). This variability, after a long period of cold and dry climate in the second-half of the YD may have delayed or modified any predicted return to hunter-gatherer behaviours seen in the previous, generally, warm phase of the Allerød. The cold phase during the Allerød occurred at the end of this period, where hunter-gatherers had presumably set up a long-term and robust settlement and subsistence strategy based on ca. 1000 years of warmer environments and the associated flora and fauna, and it took the dramatic and long-term downturn of the YD to force a shift away from these strategies. In contrast, the brief downturn/s during the PB occurred relatively shortly after the YD (ca. 100 to 200 years after the initial warming phase), where it is possible no such robust strategy was yet in place, thus possibly affecting the predicted hunter-gatherer behavioural responses to what is generally expected in warm and favourable periods.

The two phases of the YD is more of an issue in terms of interpreting hunter-gatherer behaviours. These two phases are considerably longer (ca. 400 and 700 years respectively) and may have indeed affected hunter-gatherer behaviours. These phases are also long enough that many of the assemblages collected in this study would fall into one or the other phase. However, unfortunately, very few of the assemblages in this study can be reliably dated to these phases due to the majority being attributed to the general "Younger Dryas" through tool typology or through pollen records. As such the sample size for each phase is too low to be able to compare reliably, especially in the case of the first-half of the YD. This being the case, it was decided to assume that, for the purposes of this study, that the YD is one homogenous cold and harsh period, although future research should look to resolve this.

When comparing the northwest environmental data to that of south Europe, we see remarkably similar climatic and environmental patterns, but with more subdued temperatures. There is a dramatic opening of the landscape after the Allerød into the YD in many regions, with an increase in steppe-tundra plant species, which is followed by a rapid reforestation during the PB. Also, the cold, dry, Allerød phase, and PBO events are both evident, with associated decreases in lake-levels, and there is evidence for a warmer, drier second-half of the YD. However, there are notable differences. There is evidence for the persistence of warm climate trees, such as oak, into the YD, which indicates that conditions in the south were not as harsh as in the north. Also, the YD appears to be drier throughout in the south, with an initial cold, dry phase, followed by a warm, dry phase. Lake-levels dropped significantly at the onset of the YD and remained low until the PB, which we only see during the second-half of the YD in the northwest. Additionally, several studies observe different environmental responses between high and low elevations, which is most likely a factor of the south European regional geography having highly mountainous terrain, unlike in the northwest. This might have been a factor in creating zones of refugia for human populations to continue their warmer climate strategies. The Mediterranean also created a subdued environmental response to the YD in regions close to the coast, where there has been shown to be relative environmental continuity from the Allerød to the YD, again suggesting that human populations could continue their behavioural strategies unchanged into the YD in the coastal zones. Ideally it would be a better strategy to compare the south European regions according to their geographical area, such as coastal and high/low elevations, but again, doing so would decrease assemblage sample size to such a degree that comparisons would not be possible. Therefore, for the purposes of this study, the south of Europe will be considered as having similar environmental responses from the Allerød, into the YD, and through to the PB, as to the northwest, but with notably more subdued temperatures. Again, future research should look to resolve this.

Chapter 2: Theory and Methods

2.1 - Introduction

In order to understand the relationship, if any, between hunter-gatherer mobility change and climate change, one must first predict the preferred mobility strategy practised in warm climates compared with colder climates. This can be a problematic issue and has been debated for several decades without any real consensus. Once this issue is addressed, it will be required to further predict the type of mobility practised at any one site, at any one time, using only the material indicators from the archaeological record. The difficulties in formulating these predictions are rooted in the fact we are dealing with extinct hunter-gatherer populations with no real comparable modern examples with which to relate, especially populations that make extensive use of stone tool technology, a technology that represents a significant proportion of the Palaeolithic and Mesolithic material culture. This issue is impossible to resolve, hence, many of the theories and models for understanding prehistoric hunter-gatherer populations are based purely on estimations, and best guesses.

Ideally, multiple lines of evidence should be utilised together, such as stone tools, faunal remains, and C^{14} frequencies to name a few, in order to gain the best understanding into hunter-gatherer behaviour. However, in the region of northwest Europe that is focused upon in this study, organic preservation is highly variable and large areas of Belgium, the Netherlands, and northern Germany have little-to-no organic preservation. Due to the differential preservation across northwest Europe, the main focus of analysis will be upon stone tool remains which are well preserved throughout the research area.

This chapter will firstly discuss and critique the various arguments surrounding hunter-gatherer mobility from currently accepted archaeological and ethnological research. Through this discussion, a formalised methodology will be presented to enable predictions as to the type of mobility strategy practised by hunter-gatherers based on the material record of prehistoric sites. This will be achieved by interpreting stone tool assemblage data from sites belonging to interstadial and stadial climatic events that occurred during the Pleistocene/Holocene transition from ca. 14,000 cal BP to 10,000 cal BP, i.e. the Allerød, YD, and PB.

2.2 - Theoretical Background

2.2a - Definitions of Residential and Logistical Mobility Strategies

This research will focus on two commonly accepted types of hunter-gatherer mobility strategies; residential and logistical. Residential mobility, defined by Binford (1980), comprise movements of the residential group from one settlement to another, as resources become available in different areas at different seasons. This is characterised by regular residential moves and the exploitation of areas immediately surrounding residential locations. In contrast, in a logistical mobility strategy, groups carry out frequent and long-distance logistic forays from residential locations to simultaneously exploit two or more critical resources, distantly separated in the landscape. Hence, residential mobility involves movement by an entire group leaving one area for another, with the same or similar activities being carried out at successive residential locations. Logistical mobility strategies involve specialised moves carried out by specialised task groups at specialised task camps away from the residential camp. In this strategy, it is the resources that are moved to the residential group rather than the residential group moving to the resource (Binford, 1980).

Archaeologists commonly approach settlement organisation and mobility strategies using this principle of residential and logistical mobility. When using this model there is a consensus that in a residential strategy there will be generally one site type, namely residential camps, which are occupied for short periods of time. In contrast, in a logistical strategy, there will be a base camp and also several special-task camps distributed over the landscape presumably at key resource locations. In general terms, residential mobility is an effective strategy when a variety of overlapping resource zones can be easily exploited by small groups. However, logistical mobility is preferable when a key resource determines site location as a result of its importance to a group, or when competition forces a group to concentrate its subsistence activities in one location (Lurie, 1989).

Residential camps in a residential strategy are occupied by a 'microband' which exploit resources in the local vicinity. These camps are occupied for a short time, possibly less than a season, following resources as they become available. In a logistical system, Lurie (1989) identifies three site types: base camps; residential camps; and extractive camps (special-task camps). Base camps may be occupied by more than one band or a 'macroband' and will be located near to an abundant resource. This base camp will remain occupied until that resource is no longer available, and would be seasonally occupied, if not longer. Extraction camps are short-term, limited activity camps, which would be occupied by producers only. Thomas (1989) also makes the further distinction of a fourth site type, 'locations', which are used for short foraging or collecting trips which are diurnal, and thereby more ephemeral in nature. This site type may be expected in both residential and logistical mobility strategies close to the residential base camp. Lurie (1989) states base camps are the defining characteristic of more permanent, logistical settlement systems, but residential camps could be seen as part of a residentially mobile strategy and also as part of a more permanent logistical mobile strategy. Thus, in archaeological terms, a residential strategy would be expected to leave behind only residential camps with a discrete scatter of activity close by, while a logistical strategy would be expected to leave behind fewer residential camps and a variety of other sites, such as hunting and butchery camps, storage caches, and lookout posts, along with an increase in storage and food preservation (Binford, 1980).

However, Binford's model has been criticised for overly simplifying hunter-gatherer decisions, and creating a dichotomy between these two strategies, when in fact most groups, would have employed a mixture of these two systems, or even alternative strategies not recognised in either system (Odell, 2001). Additionally, Kelly (1983) showed a hunter-gatherer group's mobility strategy may change from one year to the next, and thus adding a potential source of confusion when making interpretations based on single sites, especially sites that were sporadically occupied. However, despite these criticisms, Binford's collector/forager model provides a valuable framework on which to build interpretations based on archaeological data (Odell, 2001).

So what kind of settlement strategy can be predicted for a warm interstadial climate such as the Allerød and PB, compared with a cold stadial climate similar to that of the YD? From the environmental data from northwest Europe, it is evident the YD was significantly colder than the preceding Allerød and the subsequent PB. During the Allerød and PB the mean July temperatures in northwest Europe have been estimated to be between 15^{o}C-17^{o}C (Hoek and Bohncke, 2002) in comparison to as low as 9^{o}C-11^{o}C during the YD (Walker et al., 1993; Isarin and Bohncke, 1999). Mean January temperatures dropped from between -16^{o}C-6^{o}C to between -15^{o}C and -7^{o}C, which would have brought a decline in the mean annual temperature to below -1^{o}C (probably between -2^{o}C and -5^{o}C, and possibly as low as -8^{o}C to -4^{o}C), and allowed the development of a discontinuous permafrost over much of this region (Bohncke, 1993; Hoek and Bohncke, 2002; Stevens et al., 2008). The environmental landscape also changed quite drastically from dense woodland in the Allerød, to scrubland and sedges with sparse woodland in the YD, back to dense woodland in the PB (Hunt and Birks, 1982; Walker et al., 2003; Coope and Joachim, 1980; Innes et al., 2009; Hoek, 1997; Hoek and Bohncke, 2002; Crombé and Verbruggen, 2002; Crombé et al., 2011).

Binford (1980) suggests the level of logistical mobility increases with increased climatic severity when growing seasons are shorter. Therefore, a logistical mobility pattern should be related more with cold climates, while residential mobility patterns are related more with warmer climates. Importantly, he notes, there are other factors affecting mobility, such as increased numbers of social units in the area, and competition among multiple social units for access to similar resources. Due to this, it is predicted here, during the cold conditions of the YD, a more logistical strategy would have been employed (as some believe may also have been utilised during the Last Glacial Maximum i.e. Straus, 1991; Barton et al., 2007) to effectively exploit and survive in a landscape that would have been much harsher, with more open conditions, compared with the Allerød and PB. This is in contrast to the prediction of a more residential strategy during the warmer interstadials, where conditions would favour moving around the landscape and to take advantage of resources as they became available. It is important to emphasise here, it is highly unlikely any population would purely exhibit the characteristics of one strategy or the other, but rather a mix of both (as outlined by Binford, 1980) depending on the exact circumstances encountered within their specific environments. With this in mind, it should be noted, the statement made within this study of a “more” or a “less” residentially or logistically mobile population is meant to highlight it is expected human populations during the YD would have moved to a settlement strategy in which the characteristics would be “more” similar to a logistical strategy and “less” similar to a residential strategy, with the opposite being the case during the warmer interstadial periods**.**

2.2b - Foraging Theory and Predictions of Hunter-gatherer Behaviour

The study of prehistoric hunter-gatherer populations commonly incorporates economic models such as ‘Foraging Theory’ often used in the study of non-human foragers. However, due to its origins in non-human subsistence behaviour, it is thought that many aspects of this model are inadequate when translated to human hunter-gatherer behaviour (Durham 1981; Jochim 1983, 1988). Despite this, many archaeologists see optimal foraging models as providing a systematic framework for analysing human foraging behaviour, providing a suitable starting point for predicting prehistoric hunter-gatherer behaviour based on archaeological remains (Bousman, 1993).

In basic terms, Optimal Foraging Theory comprises a number of models based on microeconomics and game theory, and has two primary models that consider the costs and benefits of acquiring different resources: prey and patch models (MacArthur and Pianka 1966; Charnov, 1976). Prey models consider hunting or gathering individual prey in homogeneous environments, while patch models consider acquiring food from clusters of prey in spatially heterogeneous environments (Bousman, 1993). Optimal foraging models usually measure returns as energy obtained from food, while costs are often measured in terms of time expended on search and handling activities. Search costs represent the amount of time spent looking for either prey or patches, while handling costs consist of time spent in pursuit, capture, preparation, and consumption of food resources (Bousman, 1993). Bousman (1993) suggests it is important to include costs of technological production and transportation of tools and materials when considering handling costs. He highlights the importance of advantages technology can have on increasing net food returns through use of more efficient or effective extractive tools, such as bow-and-arrows and traps, along with decreasing search time by use of transportation facilities (such as canoes or snowshoes). However, he notes technology also has its costs in manufacture and maintenance.

The classically accepted prey model proposes hunter-gatherers attempt to maximise returns while considering the costs and yields of different prey species, and through this can give an estimate of diet breadth (MacArthur and Pianka, 1966). For a single hunter-gatherer group, prey is ranked from high to low energy costs. This is commonly determined by prey size, density, distribution, and the technology used to exploit prey. However, there are other factors that should be considered. Jochim (1976) found fat content and palatability, along with a balance between carbohydrates and fat versus lean meat, may also be important contributing factors when ranking prey. This model assumes hunter-gatherers exploit the most profitable resources first and then add increasingly less profitable resources to their diet if needed. As new resources are added, the time spent in searching for food resources decrease because they are encountered more often. However, importantly, the handling costs also increase. There is a point where decreasing search costs are balanced by higher handling costs, and the addition of new resources would lead to an imbalance in terms of less efficient time/energy expenditure, and it is this balance that represents an optimal diet. If handling costs decrease because of less expensive technologies, such as the use of multifunctional and/or generalised tools or more easily obtained raw materials, then this model predicts broader diets. This would be more in line with definitions of hunter-gatherer populations operating within a residentially mobile system. In contrast, narrower diets are predicted if more expensive technological strategies (e.g. a diverse set of specialised weapons) increase handling costs. This behaviour can be related to the definitions of hunter-gatherers operating within a logistically mobile system. However, if search costs decrease because of greater resource density or the utilisation of transportation facilities and hunting traps, then this model also predicts narrower diets. However, crucially, if search costs increase because climatic and/or environmental changes cause food scarcity, then diets should become more diverse (Bousman, 1993). This behaviour may be linked directly to the possible human responses to the YD stadial event that is the focus of this study.

Prey models usually incorrectly assume resources have a homogeneous distribution in the landscape. In contrast, patch models consider foraging strategies in environments with a heterogeneous distribution of resources which are found grouped in 'patches'. This patch model assumes resource return rates diminish exponentially as foraging time in a patch increases (Kaplan and Hill, 1992). However, as search time between patches increases, the time spent in a patch will also increase in an attempt to mitigate search costs. Therefore, as patch density increases, so does the net energy gain, as foragers spend less time travelling between patches and more time exploiting resource patches, at least during the initial period of patch exploitation when the return rates are at their highest (Bousman, 1993). However, some technological strategies directly influence resource return rates, and these can increase or decrease the net energy gain. Although, if this was the case, it may be expected that greater resource return rates would allow more search time between patches, or provide more time for non-subsistence activities (Bousman, 1993).

In an environment characterised by patchiness because resource availability varies through time and across space, the most efficient way for hunter-gatherers to organise themselves is to practise residential mobility, i.e. to schedule themselves to be in the right place at the right time. As long as population density remains low, this strategy works efficiently, but if population density increases, it has been suggested residential mobility becomes non-adaptive (Vierra, 1983; Jeske, 1989).

One of the fundamental principles of behavioural ecology, is that aspects of the environment and characteristics of human populations determine how hunter-gatherer groups move around and exploit food resources in the landscape (Binford, 1980, 2001; Kelly, 1983, 1995). Kelly (1983; 1995) proposes there are several important relationships between effective temperature (ET), plant productivity, and patterns of forager mobility. It is considered the number of annual residential moves carried out by foragers can be directly related to the ET and overall plant productivity. The mean distance of residential moves has also been considered inversely proportional to ET. Essentially, in areas with high ET, long growing seasons, and high plant productivity, hunter-gatherers maximise their foraging efficiency by making frequent, short-distance, and relatively random residential moves. This occurs when the resources in the immediate vicinity of the residential camp are exploited to the point that foraging efficiency begins to significantly decline. It is also considered territory size is inversely proportional to ET, and territory size is directly related with the percentage contribution of hunting in the overall diet. This means territory sizes must be larger in locations where there is low plant productivity and where hunting is the primary subsistence objective. Increased hunting activity also requires large territory sizes, particularly in unproductive areas, and there is a clear inverse relationship between plant productivity and the dependence of foragers on hunting and fishing (Binford, 2001; Kelly, 1995). The reason being, when plant resources are scarce, there must be an increased focus on the exploitation of non-plant resources for subsistence. This could lead to the expectation of a residential mobility strategy more dependent on generalised subsistence during the relatively high ET of the Allerød and PB interstadials either side of the Pleistocene/Holocene Transition, and a less residentially mobile (possibly more logistical) strategy, more dependent on hunting during the low ET of YD Stadial.

Kent (1992; 1991) and Kent and Vierich (1989) propose anticipated mobility, i.e. the length of time groups plan to occupy a camp, is a significant and strong predictor of site size, number and size of structures, numbers of features, and the presence of formal storage facilities, rather than the actual time a group spends at a camp. The presence of formal storage facilities is the result of accumulation of goods based on anticipated restricted mobility. Thus, formal storage is not based on economic objectives, actual length of occupation, season of occupation, or other variables commonly assumed to influence the presence of these facilities. Groups who do not anticipate a short occupation will not construct elaborate structures demanding a high expenditure of energy in construction and material sourcing and procurement. They will also not use formal refuse loci, such as middens. A study was carried out by Kent and Vierich (1989) on ethnographic data collected from the Basarwa (Bushman, San) and Bakgalagadi (Bantu speakers) of the Kalahari Desert, Botswana. The variables analysed were: the actual length a site was occupied; site population; season of occupation; subsistence orientation; and ethnicity. They found anticipated occupation was a stronger predictor than actual length of occupation, but the record visible to the archaeologist would not provide a complete picture. One example given is a Basarwa camp where the residents built three storage platforms and used a midden in anticipation of a long occupation, though the camp was abandoned after only three weeks. Other sites saw inhabitants that anticipated a short occupation in fact stayed for a longer, and at one such camp, no formal storage facilities were constructed or middens used. These examples show that the presence of storage facilities and refuse loci were conditioned more by how long inhabitants planned to stay rather than how long they did, although they note in most cases, anticipated and actual coincide. This research may be of significance to the study presented here. Just because the composition of an archaeological assemblage from a site may resemble a short or long occupation stay, it does not necessarily mean it was planned to be in the context of a group's general mobility strategy. If this is so, then indicators such as site size, formal storage and refuse facilities, and quantity/density of material must be considered with this in mind.

2.2c - Problems with Theoretical Models

To understand how this theoretical background can help form models to determine prehistoric hunter-gatherer mobility, one must also understand the inherent problems associated with these, sometimes simplistic, hypotheses. Kuhn and Clark (2015) stress the typical 'Binfordian' models are founded in ethnographic scales of observation, and note this can lead to a miss-match in analytical scale between the behavioural dynamics of hunter-gatherer populations and the archaeological evidence. Variation in hunter-gatherer mobility and artefact production, in the scale of days or seasons, are mapped directly onto archaeological assemblages that accumulated over centuries or longer. Two responses are often employed to attempt to overcome this miss-match. The first is to concentrate on the best-preserved sites with intact stratigraphies, which can be resembled more closely to an 'ethnographic' scale of resolution. The second is to accept the coarse chronological resolution found at many sites and to consider how human events that occurred at comparatively brief timescales might be expressed at longer timescales (Kuhn and Clark, 2015).

2.3 - The Use of Stone Tool Assemblages in the Analysis of Hunter-Gatherer Behaviour

Stone tools represent the most common and consistently recorded form of cultural material from the area of northwest Europe focused upon in this study. The main reason being there is poor organic preservation in large areas of this region (northern Belgium, the Netherlands, and northern Germany) and thus faunal remains are rarely represented in site assemblages and if they are, they are represented in small numbers. Hence, analysis and interpretation of stone tool assemblages will form the focus of determining levels of mobility both at an inter and intra site level.

The study of stone tool assemblages is commonly set in a background of OFT and cost benefit studies described earlier. Since reproductive or inclusive fitness is often used as a measure of human adaptation, understanding hunter-gatherer subsistence behaviour is highly useful in the study of prehistoric societies (Winterhalder, 1981; Jochim, 1989; Lurie, 1989). Humans must eat to survive and many ethnographically recorded hunter-gatherer societies spend a substantial portion of their available time and energy in subsistence related activities. As procuring and processing food resources requires time and energy, it follows that these activities take away time and energy from other activities that might affect reproductive success, such as defence and social interaction. Thus, it is important for hunter-gatherers to be efficient in their subsistence activities to ensure the success of their group (Lurie, 1989). Tool design, manufacture, and maintenance should be seen as an attempt to increase subsistence efficiency, and foraging theory is one approach that allows archaeologists to understand the behaviours responsible for the choices made in manufacture, use, and maintenance of stone tools and waste products in hunter-gatherer populations (Bousman, 1993; Torrence, 1983; 1989).

Assuming this is true of prehistoric hunter-gatherer societies, it would be logical to relate stone tool technologies to the economic models used in the study of subsistence behaviour. Lurie (1989) provides three reasons to support this relationship. Firstly, technology can increase efficiency in food (and other raw material) procurement. Secondly, tools and facilities (e.g. containers) are often important costs that should be included in optimisation studies. Thirdly, prehistoric hunter-gatherers were capable of manufacturing tools in several ways, and they would have been faced with making choices in toolkit type and composition that suited their needs within an environmental system.

2.3a - Expedient versus Formal Tools and Raw Material Availability

Binford (1973; 1977; 1979) originally described hunter-gatherer technological organisation as a continuum ranging from curated to expedient tool manufacture. He proposed technological strategies based on curation will comprise tools that are effective for a variety of tasks, are manufactured in anticipation of use, maintained through a number of uses, transported from location to location, and modified/recycled for other tasks when no longer useful for their primary function. In contrast, technological strategies based on expediency will comprise tools manufactured, used, and discarded according to their immediate needs. Thus, curation should produce formally distinct, technologically sophisticated, assemblages, with individual tools used for a variety of anticipated purposes. While expediency should produce simpler and formally less sophisticated tool assemblages, because tool manufacture is an immediate response to the specific task at hand (Binford 1979). Hence, it is proposed the number of expedient and formal tools within a lithic assemblage can be a means of recognising hunter-gatherer mobility strategies.

Formal tools are defined as having more time and effort invested into their manufacture along with a level of advance preparation. They are generally thought to be used for long periods of time and more intensively maintained to increase their use-life. Andrefsky (1998) associated more mobile groups with formal tools, as these groups cannot risk being unprepared for a task while on the move. Unprepared, in this context, means not having available tools to complete tasks, and thus more mobile groups reduce this risk by transporting tools with them. Therefore, these tools have the characteristics of being multifunctional, readily modifiable, and easily portable (Andrefsky, 1998). In contrast, Andrefsky (1994) defines informal tools (including expedient tools) as unstandardised or casual in terms of form. These tools are thought to have been manufactured, used, and discarded over a short time period. Binford (1979) describes informal tools as tools that are manufactured and utilised in response to specific conditions rather than in anticipation of future events.

Expedient tool production is more wasteful than formal tool production, with the raw materials employed in their manufacture being used less efficiently. As a result, the tools produced through an expedient manufacturing strategy tend to be simpler and have less formal patterning in shape and/or design (Andrefsky, 1994). Andrefsky (1994) expects expedient tools should be associated with more sedentary populations, as it is not necessary for these groups to spend extra time and effort in the production of formal tools. Increasing sedentism may decrease the abundance of resources available to them as they become increasingly reliant on relatively more permanent residential locations and key subsistence resources. However, importantly, carrying costs of tools are no longer a constraint as they do not need to consider weight restrictions, and expedient tools require a considerably lower amount of work in their manufacture. Also, ethnographic and archaeological studies have shown lithic production components such as non-retouched flakes and bipolar shatter are capable of completing most tasks (Andrefsky, 1994). A list of expectations of costs for expedient and formal tools are set out in Table 2.1 for expected toolkit characteristics in mobile and sedentary populations.

Costs	Expedient Tools	Formal Tools
Manufacturing costs	Low	High
Raw material wastage	High	Low
Use-life	Short	Long
Multifunctional capability	Low	High
Portability	Low	High

(Table 2.1: Costs of expedient versus formal tools in hunter-gatherer societies (modified after Andrefsky, 1994))

The manufacture of expedient tools involves minimal shaping of cores, and tools are selected from some of the flakes and blades that are removed. There is less predictability in size and shape of the blanks and more wastage of the core. Little or no modification is applied to these blanks prior to use and core reduction can be carried out on raw materials of varying size and quality. Expediently manufactured lithic assemblages are typically characterised by high proportions of cores and tools with minimal retouch and signs of utilisation (Parry and Kelly, 1987; Torrence, 1989; Young, 1994).

Parry and Kelly (1987) argue, in situations where the transport of tools is unnecessary, hunter-gatherer groups will not take the extra time and effort needed for standardised core reduction and the manufacture of facially retouched tools. In these situations, a more expedient technology should be expected. In their study of the Homol'ovi hunter-gatherer groups, from areas of the Southwest U.S., they used three criteria to identify differences in lithic assemblages: the biface-to-core ratio; the proportion of formal tools in the retouched tool assemblage; and the relative frequency of flakes in the debitage assemblage. They found with increasing sedentism there was a decrease in the proportion of tools that showed evidence of facial thinning, such as projectile points, bifaces, and scrapers, suggesting a lesser emphasis on multifunctional tools and a shift to a more expedient technology. It was also concluded ‘limited-activity’ sites in mobile populations should be expected to have a higher biface-to-core ratio, more formal tools, and a higher percentage of prepared platforms than those in more sedentary populations.

Bousman (1993), when considering what mobility type might use formal versus expedient tools, suggests foragers (more residentially mobile populations) prefer increased use-life with their extractive tools, and would have less maintenance costs. Therefore, it should be expected, in relation to tool production, that foragers are ‘time minimisers’. In contrast, collectors (more logistically mobile populations) prefer increased effectiveness in their extractive tools rather than use-life, which results in higher costs in their maintenance. Effectiveness, in this regard, relates to efficiency, therefore collectors could be expected to be resource ‘maximisers’. Thus, foragers can be more relaxed in terms of tool production and maintenance compared with collectors (Bousman, 1993). A collector strategy of greater toolkit diversity (i.e. tool specialisation) and complexity, along with a dependence on reliable tools with intensive maintenance strategies, should be seen as an adaption to respond to specific resource availability. In contrast, forager strategies of a more simplified toolkit composed of multifunctional tools, the exhaustion of extractive tools, and low costs in maintenance, should be seen as a response to the ability to exploit a wider range of more unpredictable resources that can be easily and regularly obtained. Bousman (1993) further highlights three factors for predicting expedient versus formal tools:

1) Raw material durability
2) Raw material access
3) Traditions in lithic tool manufacture

Different raw materials have different fracture and wear characteristics which can influence the length of a tool's use-life. Raw material availability/access would be a function of the degree of mobility, range size, and exchange networks. Finally, traditions in lithic tool manufacture may limit technological change.

However, Myers (1989) proposes the opposite view that, when a subsistence strategy is focussed around a diverse set of low-risk resources available throughout the year, expedient tool manufacturing, and maintenance strategies should be expected to be employed. This creates the expectation, when there is a reliance on the high-risk hunting of temporally and spatially dispersed game animals, a more formal tool and maintenance strategy would be used to minimise the risk. Whether this model is expected or not, it should be possible to identify contrasts in the scheduling of subsistence and technological activities when comparing collector and forager societies (Myers, 1989). Collector societies should be expected to schedule tool manufacture and maintenance activities outside of periods of time-stressed food procurement, while forager societies should be expected to more regularly perform subsistence and tool manufacture and maintenance activities at the same time (Zvelebil, 1984; Myers, 1989).

In situations where the transport of tools is necessary, hunter-gatherers prefer to utilise portable, versatile, technology (Kelly and Todd, 1988; Parry and Kelly, 1987). As transport of tools is less critical in more sedentary populations it should be expected the lithic assemblages of sedentary groups should differ from highly mobile groups (Young, 1994). It has been argued portable and versatile lithic assemblages are commonly manufactured using standardised core reduction techniques (Parry and Kelly, 1987), which involve the preparation of cores for removing blanks in a predictable way. This technique produces blanks of relatively uniform size and shape with minimal waste of raw material. These blanks can then be made into formal tools used in a wide variety of tasks. The unmodified blanks may also be used as tools.

Tools that are facially retouched or facially thinned are generally considered to be multifunctional (Parry and Kelly, 1987; Young, 1994). However, the more complex thinning of tools such as projectile points require training, skill, and time to manufacture. In addition, good quality raw materials with few flaws are also needed. However, Close (1996) has shown, from her work on the Safsaf Sandsheet, eastern Sahara, portability may not be an important factor in tool design choices. She found, where there are no outcrops of rock, prehistoric people prioritised anticipated activity and serviceability rather than portability.

2.3b - Use-Life and Tool Curation

The use-life of tools is often associated with levels of retouch and it is common to determine function, use-life, and intensity of use of a tool by studying this retouch. Generally, it is thought the more a tool is retouched the further along that tool is in its life-history, and the longer it has been curated (Andrefsky, 2009). Reduction and retouch intensities have been often regarded as one of the best ways to determine the extent of utilisation of lithic artefacts, and thus reduction or retouch intensities are used as a proxy of tool curation length and its relationship to mobility. In one such study by Blades (2003), a relationship was found between less intense endscraper reduction, increased percentages of distant raw materials, and reindeer-dominated fauna during cold and apparently open environmental conditions. In contrast, he found less consistency in the extent of endscraper reduction within assemblages associated with more diverse and less mobile fauna in more closed environments during milder climatic conditions. Rolland and Dibble (1990) who, in their study of lithic reduction intensity in the French Middle Palaeolithic, also interpret lower numbers of unretouched flakes compared with retouched flakes within a lithic assemblage to reflect a more intensive use of lithic resources. However, they propose greater intensity of retouch was related to the greater accumulation of reindeer remains and their resulting processing at winter residences. Therefore, this can be subsequently related to a reduction in mobility. The latter example highlights an important issue to consider. Although, use-life and use-intensity studies of tools can help us gain a clearer understanding of tool manufacturing strategies, site function must also be a consideration. Hunter-gatherers will use, maintain and discard tools in different ways at different site types (e.g. the greater use and discard of expedient tools at kill/butchery sites than at residential base camps) (Bousman, 1993) and making assumptions based on a handful of sites in any one system may be unrepresentative of the wider technological strategy as a whole. These strategies may also vary depending on the season of use, as Rolland and Dibble (1990) show.

Andrefsky (2009), when studying use-life and curation in lithic assemblages, highlights it is vital to understand that stone tools often undergo a series of transformations from the time they are initially produced until the time they are discarded. These transformations relate to a wide range of possible social and economic situations within or between populations. For example: tools are sharpened when they become dull; reconfigured or discarded when broken; and modified to suit a certain task in a certain context. These processes are often coined as 'life-histories' and lithic tools can change in their morphology throughout their use-life (Andrefsky, 2009). Tools can also drastically change in function, a flake blank originally used for cutting meat may be modified into a serrated edge used for sawing. This saw tool can then be intentionally chipped and shaped into a projectile point, and in this way a single tool can undergo several transformations during its use-life. To further complicate matters, unintentional morphological transformations of tools may come about through the gradual use and resharpening of the tool over time (Andrefsky, 2009). Thus, determining stone tool use-life histories through studying retouch is fraught with difficulty. It is difficult to identify the lithic elements of a curated tool kit in the archaeological record, since the individual components will enter the record only as they are broken, lost, or abandoned and rarely, if ever, as a complete tool kit. Close (1996) suggests we should instead consider the material recovered from the whole area or region of study and not just from individual sites. Andrefsky (2009) highlights the problems associated with the variability of retouch strategies from tool to tool. He notes some tool types, such as flake knives, have no separate production and use phases and are simply retouched as needed, resulting in morphological transformations only during use and resharpening. In contrast, tool types such as projectile points, have distinct production, and use phases where they are not used until after they have been retouched in the initial production stage. Also, projectile points may be retouched again after their initial use. Further to recognising and understanding retouch strategies, additional problems can arise from post-deposition processes. The effects of post-depositional trampling on lithic artefacts can significantly affect the appearance of a tool, giving the effect of intentional retouch or use-wear, and possibly affecting the functional and typological classification (Odell, 2001).

These examples show it is not only crucial, when using retouch as a proxy for artefact function and curation, to be able to distinguish between different kinds of retouch and retouch strategies (Andrefsky, 2009), but also to understand any observable retouch may have come about through post-deposition processes. Determining frequency and intensity of retouch is difficult in the dataset compiled in this study as detailed descriptions of retouch, such as number of retouched edges, type of retouch, and length of retouched edges, are not consistently available, if at all, although information on the number of retouched edges is the most widely reported.

Tool curation can also be understood in terms of tool discard, which can be both purposeful and accidental. In general, it should be expected tool discard results from a variety of different scenarios, such as breakage during manufacture, discard after use, breakage, during transport, tools cached and never recovered, or discarded if no longer maintainable (Gould, 1980; Kuhn, 1989; Shott, 1989; Bousman, 1993). Ammerman and Feldman (1974) suggested three elements affect the relative frequencies of artefacts at sites: the relative frequency of each activity, the 'mapping' relations between tools and activities, and the tool droppage rate (or probability a tool is abandoned and incorporated into the archaeological record). Droppage rate reflects the use-life of a tool and can be affected by raw material quality, intensity of use, tool efficiency, and intensity of maintenance, among other factors. They note this droppage rate is regularly underestimated when considering the formation of archaeological assemblages.

Tool curation can be directly linked to expedient versus formal tool manufacturing strategies and aspects of energy and/or time efficiency in resource procurement and processing. It is generally assumed efficiency is one of the driving forces behind choices in technological design and thereby adaptation (i.e. formal tools are more efficient in a highly mobile population while expedient tools are more efficient in a more sedentary population). Bamforth (1986) disagrees with this concept. He notes the characteristics of the classic models of formal or curated technologies versus expedient technologies (outlined by Binford, 1980) are far too broad and there is no reason why all the characteristics of each tool manufacturing strategy should always occur together. He gives the example of flake knives in the U.S. Plains bison kills, which were manufactured in preparation for a kill, resharpened occasionally during butchering, and then neither used for other tasks, modified/recycled, nor transported to other locations. He proposes different aspects of curation are adaptations to different circumstances, implying no single measure of technological 'efficiency' can be universally applied to all hunter-gatherer populations. In the context of tool manufacture, energy expended in production is likely to be an important variable affecting economising behaviour, but its importance will vary under different conditions. In areas of poor lithic raw material availability, raw material conservation may be more important than efficient energy expenditure during manufacture. He further criticises Torrence's (1983) 'time-stressed' hypothesis that explains the manufacture of tools in advance of use, as it is far too simplistic and does not take into account other aspects of curation. He believes, from a goal-orientated tool user's perspective, it would not be more time or energy efficient while performing a task, to stop work to resharpen a dulled tool. It would be more efficient just to pick up another flake. Saving and recycling a worn out or broken tool during use often requires more time and energy than simply discarding it. Bamforth (1986) notes these alternatives to maintenance and modification/recycling are lower cost, only if raw material to manufacture replacement tools is immediately available. Thus, maintenance and modification/recycling should be closely related to raw material availability and not solely to settlement organisation or the time limits on the activities that tools are used. Thus, Bamforth (1986) asks why would anyone transport tools from place to place if raw material could be obtained everywhere? He criticises many theories and studies for ignoring local patterns of lithic resource availability which place constraints on technology. He proposes raw materials for tool production is a resource in the same way plants and animals are, in that its nature and distribution affect the ways in which it can be exploited. He proposes two aspects of curational behaviour, tool maintenance and recycling, provide clear examples of the importance of raw material availability to technology. He shows the intensity of maintenance and recycling appears to vary in response to raw material availability and notes shortages of raw material are caused not only by regional geology but also by patterns of behaviour that can increase or decrease the amount of raw material available.

It is also proposed in this thesis to view stone tool use intensity in terms of the quantity of lithic raw material used. A group who does not intensively retouch their tools (i.e. an expedient strategy) would in fact use a much higher quantity of raw materials, compared with a group who intensively retouches their toolkit, using significantly less quantities of raw material. Bamforth (1986) supports this, stating that increasing a tool's use-life by spending more time manufacturing it, will reduce the frequency with which raw material would have to be procured. Hence, expedient strategies might be seen as more of a 'mass production' of tools compared with more thoughtfully manufactured and longer curated formal tools.

2.3c - Raw Material Quality and Effects on Tool Manufacture

Andrefsky (1994) argues raw material availability and quality have a greater effect on lithic technology than mobility. Using ethnological and archaeological data, he found the degree of residential mobility or sedentism were less important determinates of stone tool manufacture. However, he notes, in areas of abundant high quality raw materials, concerns for transporting tools and raw materials is not as important for both mobile and sedentary groups, due to readily available raw materials. He also found the abundance and quality of raw materials may condition decisions in the manufacture of formal versus informal toolkits. He found, in general, poor quality lithic raw materials tend to be manufactured into informal tools, while high quality raw materials tend to be manufactured into formal tools, but only when high quality raw materials are in low abundance. When high quality raw materials occur in abundance, both formal and informal tools are manufactured (Andrefsky, 1994).

Andrefsky (2008) shows raw material proximity also influences the degree to which stone tools are retouched. Through his study of a forager residence site in the Great Basin, U.S., he found lithic raw materials were readily available, and hafted bifaces tended to be discarded and not resharpened after impact damage if foragers are within two days travel distance from their base camp. However, if the foragers were more than a two-day walk from their base while foraging, they will reconfigure broken hafted bifaces used as projectiles and resharpen dulled hafted bifaces used as knives. Retouch intensity on hafted bifaces was shown to directly correlate with the distance and proximity to each source.

Birdsell (1958) showed, as hunter-gatherer populations grow, group size remains constant. The reason being that hunter-gatherer groups disperse (fission) when they grow too large for stability. As numbers of groups within a region increase, the area available for exploitation by each group decreases. Consequently, competition for resources will increase and some resources may even become scarce. One might expect hunter-gatherer populations to adapt to these constraints by restructuring themselves to reduce intergroup conflict over resources.

Some groups might leave a region and others may be pushed into marginal areas. Alternatively, group conflict can be lowered by reducing mobility and adopting a pattern of logistical mobility (Binford, 1980). Such changes in settlement and mobility strategies have vital implications for lithic use strategies, including raw material selection, methods for procurement, tool curation, and discard rates. Sedentary groups would expend effort to obtain access to lithic resources located in geographically restricted areas, as a group whose territory encompasses desired raw material may have abundant supplies, but may limit access to outside groups (Jeske, 1989). As a result, for non-residents, non-local raw materials may be significantly more expensive to obtain than local raw materials. Increased expense may also result from the additional distances travelled to procure raw materials if chances to obtain lithic material while food gathering have been reduced, or through higher costs incurred while trading for material. Such differences in expense should be reflected in variations in the treatment of raw material, both in tool manufacture and discard patterns (Jeske, 1989).

Jeske (1989) notes, when raw materials become more expensive because of an increased energy expenditure, there will be two major consequences. Firstly, there would be a greater economy in the consumption of raw material. Secondly, artefact form will become more standardised. Pre-planned, standardised preforms or blanks can be removed from cores with less waste of raw material than random, amorphous flakes. One common type of standardised artefact is blades and bladelets. The pre-shaping of a core represents greater energy input, but allows for the removal of large numbers of blades from one piece of stone. Blades yield a large amount of cutting edge per unit of stone, although they are not necessarily very durable. Since blades represent a high amount of energy expenditure in manufacture, Jeske (1989) expects they will be manufactured more often on expensive rather than inexpensive raw material. Similarly, since these tool types are economical, it may be predicted expensive materials will be used more often. Therefore, expensive raw material should be used for longer before being discarded. Since a tool will tend to be repaired when the cost of replacing is greater than the cost of repair, tools made with expensive raw materials will show evidence of more frequent repair (Jeske, 1989). This is supported by the lithic assemblage analysis at Combe-Capelle Bas, France, by Roth and Dibble (1998), who found non-local cores were smaller than local cores through a higher intensity of reduction. They also found a higher percentage of non-local material was retouched.

Raw material for tool manufacture, clearly would have been an important determinate in hunter-gatherer settlement organisation and procurement strategies. However, Brantingham (2003) showed, through simulation studies, the choice of lithic raw materials may simply be a function of random encounters in the environment, and raw material procurement may not be linked to human organisational strategies.

Table 2.2 highlights the expected toolkit characteristics of mobile populations and more sedentary populations discussed in this section.

Toolkit Characteristics	Mobile Populations	Sedentary Populations
Numbers of formal tools	High	Low
Numbers of expedient tools	Low	High
Investment of time in manufacture and maintenance	High	Low
Preplanning for future events	Yes	No
Tool discard	Infrequent	Frequent
Tool curation	Long	Short
Tool modification	High	Low
Tool functionality	Multifunctional	Specialised
Portability	High	Weight not a constraint

(Table 2.2: Characteristics of toolkits from mobile populations and sedentary populations)

Raw material variability is another way to examine relative sedentism and stone tool production. Andrefsky (1998), highlights it is often assumed lithic raw material variability will be greater at sites with a shorter duration of occupation, and less at sites with greater durations of occupation. Also, it is often believed non-local raw materials are more likely to be found at shorter duration sites, and groups occupying sites for a short duration travel greater distances more often. However, relatively sedentary groups who occupy sites for longer durations, may have as large a territorial range as groups who occupy sites for a shorter time, but they may visit that range only once a year, once a decade, or less. Blades (1999) also proposes increased proportions of non-local raw materials within a lithic assemblage, may reflect an increase in long-distance mobility associated with open landscapes and the exploitation of mobile fauna.

One simple way to evaluate relative sedentism using lithic raw materials, is to count the relative frequencies of various kinds of raw materials and determine if two or more sites have significantly different raw material variability. This is an effective way of evaluating the data, but only when such data is available. Table 2.3 shows the expected characteristics of raw materials at long and short occupation sites.

Raw Material Characteristics	Long Occupation Sites	Short Occupation Sites
Raw material variability	Low	High
Percentage of local raw materials	High	Low
Percentage of non-local raw materials	Low	High
Potential territorial range	Small-large	Large
Potential coverage of territorial range	Infrequent	Frequent

(Table 2.3: Characteristics of raw materials at long and short occupation sites)

The differences in settlement organisation between mobile and more sedentary hunter-gatherer groups, and their different interactions with available sources of raw materials, would no doubt have a drastic effect on how a lithic assemblage would appear in the archaeological record. This kind of mobility organisation can be seen in the Epi-palaeolithic of southern Jordan, where seasonal mobility patterns varied from small ephemeral upland summer camps near flint sources, to large lowland winter camps located at some distance from flint sources (Odell, 2004). The greater blank/core ratio in lowland assemblages indicates exportation of flint from upland areas to areas deficient in this resource. This evidence was supported by measurements of variables related to tool manufacture. However, although the main manufacturing objective in both upland and lowland areas was the production of bladelets, the average length of primary elements and blade core facets in lowland assemblages was shorter. Also, primary elements and facets on cores from lowland sites were substantially shorter in maximum length than in upland sites, suggesting initial preparation of cores occurred at or near their origin, and before they were exported to lowland settlements (Odell, 2004). Analysis of Late Prehistoric sites along the Texas, U. S., coast further supports this (Odell, 2000), where one procurement site was close to a stone source, whereas the other sites were distant. The further a site was from the source, the lower the flake/tool ratio, the greater the percentage of bifacial thinning flakes, and the shorter the points became. This relationship is also seen from sites in New Mexico, U. S., where it has been established the mean volume of flakes became smaller with distance from the source (Odell, 2000). Table 2.4 shows the expected characteristics of lithic assemblages with increased and decreased distance from a raw material source.

Lithic Assemblage Characteristics	**Increased distance from raw material source**	**Decreased distance from raw material source**
Blank:Core Ratio	Higher	Lower
Flake:Tool Ratio	Lower	Higher
Percentage of Cortical Flakes	Lower	Higher
Average length of primary elements	Shorter	Longer
Average length of formal tools	Shorter	Longer
Blade core facets	Shorter	Longer
Retouch on tools	More	Less
Percentage of bifacial thinning flakes	Higher	Lower

(Table 2.4: Characteristics of lithic assemblages with increased and decreased distance from raw material source)

If distance to lithic raw materials affects the characteristics of a lithic assemblage, then it might be possible to link more mobile and more sedentary hunter-gatherer populations (i.e. residentially and logistically mobile) to these expected characteristics. More mobile groups are known to have a higher proportion of non-local materials within their assemblages as a result of frequent movements around the landscape. A higher level of mobility would very likely see a population being at increasing distances from raw material sources more frequently than populations who are more sedentary. More sedentary populations would likely keep a consistent distance from raw material sources as they move less frequently, seasonally, in the case of logistically mobile populations. Thus, one might expect an assemblage of a highly mobile hunter-gatherer population would have more characteristics in common to assemblages from sites at increasing distances from stone raw materials, while a less mobile population would have more characteristics in common with assemblages at decreasing distance from a raw material source. This is of course dependant on the assumption lithic raw materials are unevenly distributed and not always readily available throughout a landscape.

These characteristics closely link to issues surrounding portability, as, rather than transporting large amounts of heavy cores or nodules over long distances, only a few would be selected and consequently heavily and efficiently reduced. This would presumably be due to decisions determined by the degree of group mobility, and would lead to the selection of the lightest toolkit possible to efficiently move around the landscape. This model is logically appealing. However, it has been shown by Boesch and Boesch (1984) that wild chimpanzees, when exploiting tree species with harder nuts, preferentially transport heavier nut-cracking stones over greater distances. This asks the question whether intended use may be more important than portability, with this behaviour possibly having considerable time depth within the hominid lineage (Close, 1996).

2.4 - Diversity and Stone Tools

2.4a - Diversity in Archaeology

The concept of diversity has been extensively utilised in the field of archaeological faunal studies to analyse the characteristics of bone assemblages left from animal subsistence exploitation. The use of diversity as a measure is becoming more common in the analysis of stone tool assemblages in order to gain an understanding into subsistence and mobility strategies. As discussed, the study of stone tool assemblages commonly uses principles taken from hunter-gatherer subsistence studies. Faunal studies regularly implement diversity analyses in order to understand the composition of faunal assemblages at sites. Several of these methods can be incorporated into stone tool analysis, including the analysis of richness and evenness of an assemblage.

2.4b - Richness and Evenness

Richness and evenness are two properties, often utilised in the field of faunal studies, which can be used as a measure of comparing diversity and/or variety between lithic assemblages. Richness is the general diversity or variety of species in a collection of individuals. One of the simplest methods of calculating richness is the ‘direct species count’ (Lyman, 2008; Rindos, 1989). However, when using this method, it is important to note sample size can have a significant effect on the results. Species richness is a useful measure in which to study the diversity of an assemblage, but it does not provide information on the underlying abundance distributions. When analysing the diversity of an assemblage it is also vital to obtain information on the frequency of representation of the contributing species (Rindos, 1989). Evenness is a measure of the relative abundances of each of the species present within an assemblage and is a component of richness (Lyman 2008). A rich or diverse assemblage may not be evenly represented by its species composition, and in fact may be dominated by one species. This can show us if a species is equally abundant or if certain species are more abundant than others.

The Shannon Index is probably the most widely used and is defined as:

$$H = -\sum p_i \times \log p_i$$

Where p_i is the proportional abundance of taxa 'i' (i.e. taxa 'i' MNI or NISP / total number of taxa MNI or NISP in an assemblage) (Nagendra, 2002).

The Simpson's Index is also commonly used and is defined as:

$$1/D \text{ where } D = \sum n(n-1)/N(N-1)$$

Where 'n' is the individual MNI or NISP of each taxon in every assemblage and 'N' is the total MNI or NISP of every assemblage (Simpson, 1949).

2.4c - Problems with Sample Size

When calculating richness and evenness it is vital to understand the effect of sample size on diversity. It has been shown the number of types of species encountered in a collection increase as the total number of individual's recovered increase. To counter this problem of sample-size one should either compare collections containing equal numbers of individuals, or compare unequal samples of completely inventoried populations (Rindos, 1989). Therefore, for the purposes of this study, an assumption must be made that the entire lithic assemblage of each site has been inventoried. This is of course unlikely in many cases as the collection of lithic material from a site is highly dependent on the quality of excavation, recording, and/or publication of the data.

Problems with site reuse and site type classification

As it is critical to reliably classify site types to distinguish between residential and logistical settlement organisation, it is important to consider the problems with site type classification. Site reuse represents the most common problem when distinguishing and classifying different site types in any one mobility strategy. Thomas (1989) and Lurie (1989) both recognise this problem, noting site types and settlement organisation strategies can be affected by the high level of mobility of hunter-gatherer groups, and the nature of their seasonal exploitation of the landscape. These problems are especially pronounced in logistical settlement systems. It is highly probable logistical camps may be reoccupied at different seasons and resemble base camps in regard to the range of activities performed. Also, more intensive occupations of a site may mask previous brief, residential, and/or diurnal extraction camps, while abandoned base camps could be reoccupied as temporary special task camps. Furthermore, functionally different special task camps could be established at the same camp site, and diurnal exploitation areas may overlap spatially as seasonal resources become available (Thomas, 1989; Lurie, 1989). Taking this into account, over long periods of time, residential assemblages can become a mixture of residential and logistical strategies while logistical assemblages may represent several different and varied episodes of resource exploitation, or hidden by seasonal residential camps set-up in previous key logistical locations (Thomas, 1989).

2.5 - Expectations of Stone Tool Diversity in Hunter-gatherer Settlement Organisations

2.5a - Richness and Evenness

When considering richness and evenness on a site-to-site level in terms of residential versus logistical mobility, it would be expected in a residential strategy there would be a richer and more diverse lithic assemblage, with a higher degree of evenness representing a broader range of activities in relatively close proximity to the camp. In contrast, in a specialised hunting camp, in a logistical strategy, you would expect to see a less rich and diverse assemblage, possibly dominated by a single tool type, representing more specialised activities aimed at completing a specific task. However, a base camp in a logistical strategy may be harder to distinguish from that of a residential camp in a residential strategy as the diversity of tools represented on site in both strategies would most likely be similar if we accept base camps to be the preparation area for the manufacture of tools that are subsequently taken to special task camps. However, it might be expected residential camps in logistical strategies may exhibit a less diverse assemblage if we account for tool types taken off site to special task camps and not returned, or tools manufactured away from the residential camps at logistical sites that never have contact with the residential base.

However, when many sites are averaged over a period of time it would be expected logistically mobile populations would have a richer but less even toolkit. This would represent the increase in number of tool types expected in a more specialised subsistence strategy, and the dominance of said specialist tools at special task camps. Residentially mobile populations, on the other hand, would be expected to have less rich but more evenly distributed assemblages. This would represent the fewer number of tool types expected in a more formalised and generalist strategy and the fact most, if not all, activities (domestic and hunting) would have occurred on site, creating a more even distribution of tool types.

2.5b - Diversity in Residentially and Logistically Mobile Populations

Artefact Density, Domestic Activities, and Diversity

Jones et al., (1989) argue for an association with artefact density and variation. This leads to the expectation of low-density artefact scatters associated with foraging and/or 'energy-extraction' (or 'special task') activities and denser, more centralised or localised, artefact scatters with residential base camp activities, but only under the assumption that the rate of artefact discard can be directly related with the level of activity. They further argue a distinction can be made between domestic, maintenance and extractive activities. Domestic and maintenance activities are generally assumed to be more localised and produce a high quantity of lithic debris, while extractive activities include a wider variety of different events, producing more dispersed scatters of artefacts with a lower density. Basically, a smaller range of functions is expected to be associated with extractive activities occurring away from the residential base camp when compared with domestic and maintenance activities that are assumed to occur mainly within the residential base camp. Jones et al., (1989) note this relationship should not be considered universal across a landscape, using the example of quarry sites in the US, which often consist of large quantities of debris with low functional diversity. Assuming this simplistic model is correct, we would expect to see more variation in site density from site to site across a landscape in a logistical strategy, having a more distinct mixture of residential base camps and special task camps. In contrast, in a residential strategy, one would expect to see a more uniform level of density (that of higher density scatters) from one site to the next across a landscape due to the expected predominance of activities occurring within the base camp. However, in this study lithic assemblage density data was difficult to obtain for all the sites identified. Hence, it is proposed the total number of lithics in an assemblage be used as a proxy for density with the understanding, when site dimensions are unavailable, it is highly probable a large number of lithics may be spread across a large area, while a small number may be densely clustered and thereby not being representative of actual assemblage density.

When considering maintenance activities as an indicator of residential base camps, it may be possible to identify sites with large numbers of maintenance debris such as 'chips' (Jones et al., 1989). A site with a large number of chips may represent a site in which a large amount of maintenance activities occurred, and may in turn be an indicator of a more centralised residential base camp. However, the maintenance of only a few stone tools can create a large amount of debris, and may not be representative of the level of maintenance activities at a site. Flake artefacts may also be used as an indicator of manufacturing, and thereby a possible indicator of residential camp activities. Jones et al., (1989) propose there should be a larger proportion of flakes in residential base camp assemblages than in offsite, special task camp assemblages. Additionally, they propose the average size of onsite flakes should be expected to be smaller than those in offsite assemblages, and a smaller proportion of these flakes would show evidence of use. A further archaeological indicator for residential camps may derive from the presence of larger structural elements such as central service areas, patterned areas of sleeping, maintenance, and discard, and particularly in the case of base camps in a logistical system, storage facilities (Thomas, 1989). Kuhn and Clark (2015) also investigate changes in mobility by utilising density of artefacts, stating the frequency that artefacts are deposited at sites should reflect the number of person-hours spent at that site, noting other factors can also affect density within archaeological deposits. Another problem is density is based on sediment volume in which the artefacts are embedded, therefore, rates of sediment accumulation can have a significant effect on artefact densities independent from human activities (Kuhn and Clark, 2015).

Several studies have utilised the relationship between artefact density and the frequency of retouched tools as a potential indicator for the duration of site occupation, and to determine regional mobility patterns (Barton et al., 2011; Clark, 2008; Kuhn, 2004; Riel-Salvatore and Barton, 2004; Riel-Salvatore et al., 2008). These studies are based on the fact hunter-gatherer populations carry a certain number of artefacts with them as they travel. In extremely short stays there would be a complete reliance on the artefacts brought with them, and a few of these artefacts would enter the archaeological record. The more time people spend at a site, the greater the likelihood they will manufacture additional artefacts on site. Also, prolonged occupations would allow more opportunities to procure raw materials. Thus, decisions to use transported tools or to make new ones can be linked to the duration of occupation and can reflect the frequency of residential mobility (Kuhn and Clark, 2015). From this Kuhn and Clark (2015) propose, if rates of sedimentation hold constant, the frequency of retouched tools should be negatively correlated with artefact density. Low density deposits suggest repeated short stays and little onsite production, while high density deposits suggest longer occupations, more in-situ manufacture, and more waste flakes and debris. They take this one step further by also linking the rate of artefact deposition of different artefact classes to site complexity. If all occupations were the same, and different types of artefacts were always introduced at the site through similar manufacturing strategies, artefacts would accumulate at rates determined by the amount of time spent at a site and rate of sediment input, and under these conditions, variability in density should be the same for all classes of artefact. Thus, changes in artefact accumulation rates, should reflect more complex mobility strategies (Kuhn and Clark, 2015).

2.5c - Site Types and Expected Tool Diversity

Thomas (1989) defines the presence of three site types in a logistical strategy: base camps; logistical field camps; and diurnal extraction ‘locations’. In this model, logistical field camps and diurnal extraction ‘locations’ are expected to be limited in size and in onsite activities when compared with residential camps. However, this model differs in that, in any one logistical system, the smaller, less diverse assemblages should be viewed as areas of diurnal extraction, while intermediate assemblages (between the size and degree of diversity of residential camps and diurnal locations) should be viewed as logistic field camps. Diurnal ‘locations’ would also be a characteristic of a residentially mobile strategy, perhaps more so than in a logistical strategy, as short foraging trips to gather/collect easily obtained resources would no doubt be crucial.

Thomas (1989) finds the greatest variety of artefact and by-product producing activities occur in long-term residential camps, and as these camps are considered the centre of hunter-gatherer society, they should be generally characterised by technologically and typologically diverse assemblages. Logistical field camps, on the other hand, are commonly defined as task specific, single-sex, short-term, and ephemeral. These camps should be seen as behavioural subsets of what happens within the residential base camp, and the tool assemblages at field camps represent material culture subsets of residential base camp assemblages**.** Thomas (1989) notes it is rare an assemblage can be defined in terms of specific artefact signatures, and field camps can be expected to contain only a more homogeneous, and relatively less diverse, assemblage than the mean base camp. Further to this, diurnal extraction 'locations' should display even more task-specific technology, and assemblages associated with these sites should be the most homogeneous and least diverse, relative to size, within a given system (Thomas, 1989). He also stresses caution should be exercised when assuming this model, stating "In many (if not most) archaeological assemblages, the diversity of a sample is a direct, linear function of the size of the sample. There is a treacherous relationship between class richness and sample size" (Thomas, 1989: 86). However, he highlights it should not be thought assemblage diversity is unrelated to site function, rather the exact nature of that relationship can only be understood by focusing on the relative (rather than absolute) degree of diversity.

Thomas (1989) further recognises the relationship between number of tool classes and the number of individual tools is influenced by ecological, technological, informational, and scheduling factors, and it is important to note the degree of global assemblage diversity is not the main concern, it is the relative diversity within a given system that is key. When considering this, it is important to understand the potential 'foraging radiuses' of hunter-gatherer groups in northwest Europe to determine what constitutes the geographical range or confines of a 'system'. This will help to understand the relative diversity between sites within a single system. It is also just as crucial to recognise sites belonging to a single, contemporaneous, mobility strategy within a region to reliably compare sites that can be related to the same system.

2.5d - Tool Complexity, Resource Stress, and Diversity

A possible response to subsistence resource stress is the introduction of more efficient ways to procure food items. This is often accomplished by producing more specific or more complex tools, where specificity refers to the diversity of tools within a functional class, and the more specific a tool is to its task, the greater chance of success in the completion of that task (Lurie, 1989). Torrence (1983) points out specificity is high where resource options are limited, and the risk of failure is high. For example, the Inuit have different harpoons for hunting different aquatic animals.

Tool Complexity

Tool complexity should also be considered when thinking about diversity. Complexity, in this regard, refers to the number of items making up a tool. The greater the number of items, the more complex the tool. Shott (1986) states tool complexity may increase with tool specificity or versatility. While specificity can reduce the risk of failure, versatility can reduce the time invested in manufacturing tools by making a tool suitable for several types of tasks with little advance preparation. There is also the added advantage that broken elements, such as stone projectile points or scrapers, can be replaced without the manufacture of a completely new tool. However, an efficient toolkit has its costs, as this technology requires careful, time-consuming, and more scheduled manufacture (Lurie, 1989).

Bleed (1986) compares characteristics of prehistoric toolkits to aspects of reliability and maintainability defined by modern day engineering (see Table 2.5). He believes these concepts are more suited to the study of stone tools than concepts of 'simple' and 'complex' tools used by such authors as Torrence (1983), Shott (1989), Lurie (1989) and Oswalt (1973), noting, in the ethnographic record, toolkits defined as 'simple' or 'generalised' in archaeological studies, are quite often more complex than 'complex' or 'specialised' toolkits, thus these definitions are misleading. Thus, concepts of reliability and maintainability can be used by archaeologists to predict technological behaviour depending on environmental constraints and hunting strategies.

Reliable Systems	Maintainable systems
Overdesigned components (components made stronger than they minimally need to be)	Generally light and portable
Under-stressed (system used at less than full capacity)	Subsystems arranged in series (each part has one unique function)
Parallel subsystems and components (redundant and standby)	Specialized repair kit including ready-to-use extra components
Carefully fitted parts and generally good craftsmanship	Modular design
Generalized repair kit including basic raw materials (to affect any repair)	Design for partial function
Maintained and used at different times	Repair and maintenance occur during use
Maintained and made by specialist	Overall easily repaired – 'serviceable'

(Table 2.5: Characteristics of reliable and maintainable systems in engineering (after Bleed, 1986))

Reliable systems are made so they can be relied upon when required, whereas maintainable systems can easily be made to function if they are broken or not appropriate for a task (Bleed, 1986). Reliable systems are built with both redundant and standby components (multiple components employed for a single task). Redundant components operate in parallel and in the same way as one another. Standby components also operate in parallel but as backups to other components and come into use only when another component is not successful. Set-up and maintenance of reliable systems tend to be different from times of use and often requires maintenance and use to be carefully scheduled in advance. When maintaining a reliable system, generalised repair kits and tools are utilised that can handle any problem that may occur, as they are not designed to break down, and any problems that occur, occur unpredictably and potentially in any component. Therefore, one must be prepared to make or repair any component of a reliable system (Bleed, 1986).

Maintainable systems tend to be simpler than reliable systems. They have a series design with each component made to do its own unique job. Thus, if any component fails, the whole system fails. However, since points of failure can be predicted, maintainable systems are designed so failed components can easily be removed and replaced with a spare part making the system functional again. Individuals working with these systems often utilise a specialised repair kit that has spare parts and tools designed to carry out specific, predicted, or anticipated repairs. One way maintainable systems are made to avoid total failure is to be designed for partial function so they have some way of functioning if not at full efficiency, even after a component fails. Also, maintainable systems do not typically have a clear, scheduled, separation between the time they are used and the time of maintenance and repair (Bleed, 1986).

Overall, Bleed (1986) believes maintainable systems are preferable for generalised tasks that are continuously needed, but have unpredictable schedules and generally low failure costs. In contrast, reliability, is more important where failure cost is high and so the system must work when needed (Bleed, 1986). Assuming these definitions are true of prehistoric hunter-gatherer populations, reliable systems would be predicted to be employed for logistically mobile populations who are more sedentary in nature, predict times and locations for resource exploitation, and have less concern for weight and portability of tools. Maintainable systems would be predicted for more residentially mobile populations who move more frequently around a landscape, cannot predict when and where resources will need to be exploited as easily, and who need a more lightweight and portable toolkit. Similarly, the costs of failing to take advantage of resources at the right time in the right place in a logistical system would be much higher, especially if one links logistical mobility to harsher climatic/environmental conditions. However, in a residential system, the generalised nature of exploitation and the high frequency of moves throughout the landscape would mean the costs of failure would not be so high, especially if one links residential mobility to more favourable climatic/environmental conditions.

Resource Stress

Subsistence resources are not the only resources that may be affected by resource stress. Lurie (1989) suggests lithic raw materials may be affected by sustained exploitation and become depleted. As a result, as a location is used for longer periods of time, better quality stone may become scarce, and knappers may have to resort to using inferior material, trading, or altering the stone to improve its quality (e.g. the thermal treatment of chert). Thermal alteration comes at the cost of collecting fuel, building a hearth and the risk of failure, while trade comes at a significant cost of time and energy. If this is the case it would be expected more expensive material for tool manufacture should be used more economically, and be primarily used to make special tools that would be knapped with less waste and used more intensively (Lurie, 1989). They hypothesise, as populations aggregate, access to resources can become controlled or restricted, creating stresses similar to resource depletion. Also, larger populations are usually more socially complex and greater complexity requires more information transfer both within, and between, groups. Tools may be used to encode status markers or group identifiers and, in hunter-gatherer populations, this is likely to constitute exotic raw materials for manufacture, stylistic variation in tool form, and tool decoration. Therefore, hunter-gatherers living in a more complex social system, may expend greater time and effort in tool manufacture (Lurie, 1989). Lurie (1989:48) believes if these factors are accepted "clearly a more sedentary life-style places demands on technology that require increased investment of time and energy in tool manufacture and economics of use". However, it is the opinion here, lithic raw materials would not be subject to depletion to the same degree as food and plant resources. Rarer raw materials may be highly sought after and curated for longer, but more common raw materials would be difficult to deplete to exhaustion by a small hunter-gatherer group. For example, river cobbles used for tool manufacture at several Pleistocene/Holocene transitional sites in the UK, would be near impossible to deplete by a small group of hunter-gatherers. Moreover, if this was the case, subsequent populations in an area would increasingly have less local raw material available to them through time. However, control or restriction may well be an important factor in raw material availability as a population becomes more sedentary. It is important to note, any of these indicators may also be the result of poor availability of adequate quality raw materials, and can only be considered if the nature of raw materials in a region is known.

2.5e - Risk, Diet Shifts, and Diversity

Myers (1989) argues, in the Early British Mesolithic, due to climate amelioration and the consequent shift from migratory to non-migratory major prey species, hunting would have altered from a strategy based on intercepting animals at key locations, to a strategy limited to less predictable animal encounters. This shift may have led to the need to procure resources quickly and efficiently. It is argued the use of multi-pronged tools, using numerous microlithic components, and an increase in the diversity and reliability of the tool-kit, would have been adopted. Another effect of this shift in strategy would have been changes in patterns of raw material procurement and manufacture of tools to satisfy the increased demands on time. The scheduling of time and labour (energy) represent two key areas of 'decision making' which determine the success of an economic strategy. Levels of risk and energy expenditure would logically be dependent upon resource mobility, and unit yield. Hence, a distinction can be made between animal, plant, and water resources along with raw materials such as stone and wood. The mobility of animals introduces risk as they can avoid detection and capture. In contrast, resources such as plants, water, stone, and wood, do not carry such a risk, as they are immobile and can be reliably and routinely located within a landscape. However, in terms of cost, plant resources generally have a lower yield and small unit size, and thereby become more expensive to procure in terms of time and energy expended to resources gained. The primary limitation in exploiting plant resources is the cost of labour invested in collection, transport and processing. In contrast, the hunting of animals is primarily limited by risk (Myers, 1989). Torrence (1983) and Myers (1986) both argue the need to manage risk, determined through the use and availability of time for resource procurement, is most significant where animals are key to the subsistence strategy. Generally, hunter-gatherer societies that are heavily dependent upon the exploitation of mobile resources, especially groups in seasonally distinct environments, in terms of primary productivity, will mainly be concerned with the management and/or reduction of risks. In contrast, hunter-gatherer societies dependent upon non-mobile resources located within environments, where there are significant quantities of primary productivity available throughout the year, will be primarily concerned with managing and/or reducing costs. Risk can be managed by the adoption of a wide variety of strategies dependent on the risks involved. It may be possible to influence the spatial and/or temporal behaviour of game to elicit more favourable hunting conditions. It is also possible to change patterns of exploitation and utilise a low-risk but low-return resource to reduce the importance of animal resources to the success of the overall subsistence strategy. Also, technological responses to risk management will be expected to vary according to the nature of problems encountered in resource procurement (Myers, 1986).

To manage subsistence risk, it is important to maximise the time available, as time used for the exploitation of critical resources should not be compromised by simultaneous, non-critical activities. This can be seen by the general acceptance that lithic procurement and manufacture can be embedded within schedules to avoid overlapping with subsistence activities (Myers, 1986). Binford (1979) explains embedded strategies of raw material procurement, in providing raw materials incidental to the performance of other activities, maintain a steady supply without the need for organising task-groups that specifically collect materials. Procurement of raw materials can be carried out when the primary task has either failed or has left spare capacity for collecting, transporting, and caching these materials. This ensures, when there are periods of subsistence activity that are highly 'time-stressed', such as when conditions are favourable to heavily exploit food resources for over-wintering, these activities are not compromised by shortages of raw material or tools. In this way, periods of subsistence activity that are less time-stressed may be crucial in allowing time for procuring the necessary raw materials for those periods where the efficient use of subsistence time is required (Myers, 1986). The scheduling of tool manufacture and maintenance in advance or in anticipation of future use also represents a significant response for maximising the time for subsistence activity (Binford, 1968, 1973, 1976; Jochim, 1981; Myers, 1989). When subsistence activities are time-stressed and can be anticipated, the preparation of tool-kits well in advance of need can avoid the risks of not being able to take full advantage of critical and short-lived subsistence opportunities. This strategy may be very significant in adapting to temporally and spatially inconsistently distributed resources (Binford, 1980; Myers, 1989). Myers (1989) suggests risk reduction strategies may also be reflected in terms of assemblage composition, diversity, and complexity. Tools used in obtaining non-mobile food resources should be associated with activities where time is not a major factor, and the tools manufactured under these conditions are unlikely to be designed to reduce risk. However, weapons and facilities are associated with highly mobile food sources and often are involved in time-stressed activity. Consequently, it is expected there should be investments in design, manufacture, and maintenance of both weapons and facilities to reduce risk where possible.

Torrence (1983) found, in ethnographically documented hunter-gatherer societies, there is a correlation between increasing 'weapon' specialisation with increasing latitude. This is seen through an increase in the diversity of functionally distinct tools used in food procurement. The relationship between the diversity of weapons and latitude has been thought to reflect the increase of importance of mobile resources with increasing latitude. This would suggest, as there is an increase in critical dependence on mobile, high-risk, game, there is an increase in the number of distinct weapon types in a toolkit. Torrence (1989) did not find a correlation between 'non-weapon' implements and, as Myers (1989) notes, this might be expected as these implements would not be used to exploit high-risk resources, and would not be designed with risk reduction in mind. Therefore, assuming implements are not involved in high-risk activities, the diversity of these tool types would not be expected to change as the low level of risk would remain relatively constant with latitude. Torrence (1989) also found the total number, and per tool average, of functionally distinct component parts, could be positively correlated with latitude. These findings support the premise that increased component complexity can achieve specific benefits in risk reduction through improved efficiency in food procurement (Myers, 1989). Myers (1989) adapts this suggesting, if tools designed to perform specific tasks are expected to be more efficient in the performance of those tasks than tools designed for a broader range of tasks, then modern hunter-gatherers appear to respond to increased time-stress through toolkit diversity.

Further to Torrence's (1983) findings of increased toolkit specialisation with increasing latitude, Osborn (1999) also shows there is an inverse relationship between ET and the specialisation of hunter-gatherer tools. In low productivity, seasonal environments, foragers tend to have a more diverse toolkit with specialised functions for each tool. In high productive environments, foragers tend to carry a smaller number of tools, which are more flexible in terms of number of tasks involved. McCall (2007), notes this pattern is influenced by priori information and planning in the design of toolkits. Foragers in high productivity environments with dense resource distribution, diverse subsistence resources, and low seasonality, favour random resource encounter strategies and flexible toolkits to deal with unpredictability. Foragers in low productivity environments, with a high dependence on hunting/fishing and high seasonality, favour more targeted exploitation of specific resources, and therefore more specialised toolkits. This logistic, targeted, exploitation is necessary due to larger territory sizes and sparser distribution of resources, characteristic of low productivity environments. In these environments, random encounter strategies would lead to very low encounter rates. Thus, there is a threshold where multiple day trips become necessary to exploit distant areas of a territory, which requires a high degree of priori information about the environment, planning, and resource targeting. This is supported by Binford (1976) and Greaves (1997) who propose two technological strategies in which hunter-gatherers contend with increasing foraging distance. One strategy is to increase the number of tools carried due to the increased number of tasks expected to be carried out, while the number of uses for each tool is relatively stable. This is a characteristic of logistical strategies in low productivity environments with a high dependence on hunting/fishing. The second strategy is to increase the number of uses of each tool rather than the number of tools carried. This is characteristic of residentially mobile strategies, in high productivity environments, using random encounter strategies, and where trips are often less than one day. This strategy is a response to a lack of information about what resources will be encountered and the need for task flexibility.

Additionally, Oswalt (1973), in his study of toolkits and diets from twenty hunter-gatherer groups, has argued there is also a relationship between a population's degree of reliance on mobile resources and the complexity of its toolkit. He suggests the exploitation of mobile resources is more difficult and thus demands more complex tools than in the exploitation of immobile resources. Therefore, populations relying mainly on animals for subsistence should be expected to have more complex toolkits than populations whose diets are dominated by plant foods. He also argues, because aquatic animals are more mobile than terrestrial animals, populations depending on aquatic animals are likely to have more complex toolkits than populations relying on terrestrial animals. This disagrees with the principles of reliable and maintainable systems set out by Bleed (1986) in which 'complex' toolkits would be related to maintainable systems, which he in turn relates to the characteristics of logistically mobile populations.

2.5f - Consequences of Mobility and Population Size on Tool Diversity

Mobility

Shott (1986) proposes residential mobility influences hunter-gatherer toolkit structure due to carrying costs constraining the number of the tools a population can utilise. If this is assumed, he believes populations that move frequently and/or long distances every year will have less diverse toolkits than those that move less frequently and/or shorter distances. Therefore, tools employed by highly mobile populations will be less specialised than those used by less mobile populations since they will be utilised in a wider variety of tasks. Therefore, it should be expected artefact diversity will have an inverse relationship with residential mobility, so as mobility increases, artefact diversity decreases (see Table 2.6). Although no ethnographic data on artefact diversity were available to Shott (1986) for special-task-orientated or field camps, it would be logical to assume special-task-oriented camps, such as hunting camps, plant collecting stations, or butchering sites, would have relatively low diversity of artefacts. Thus, if a narrow range of activities were performed at a particular location, one would expect to find a relatively low number of artefact types (Andrefsky, 1998).

Shott (1986) tested this theory on a sample of fourteen historically documented hunter-gatherer populations, and found toolkit diversity and mobility frequency were significantly, negatively correlated, suggesting populations that move frequently utilise a smaller variety of tool types than more sedentary groups. However, some of his other proposed residential mobility criteria did not support his hypothesis. He found toolkit diversity was not significantly correlated with total distance covered per year, toolkit complexity was not significantly correlated with frequency of residential moves per year or the average distance covered during each move, and toolkit diversity and toolkit complexity was not significantly correlated with territory size. He also found there was a significant positive correlation between toolkit diversity and number of days at winter camps, which supports his hypothesis. However, toolkit diversity was not significantly correlated with intensity of land use, and toolkit complexity was not significantly correlated with the number of days stayed at winter camps or intensity of land use. He also found there was no significant correlation between toolkit diversity and effective temperature and net primary productivity of an environment.

Mobility and Occupation Length	**Artefact Diversity**
Residential Mobility	Low
Logistical Mobility	High
Long duration of occupation	High
Short duration of occupation	Low

(Table 2.6: Relationships of mobility and occupation length with artefact diversity)

2.5g - Population size

Shennan (2001) studied the effects of population size on toolkit complexity using population size hypotheses derived from cultural evolutionary models. He concluded larger populations have a major advantage over smaller populations in regard to cultural innovation, due to the decreasing role of sampling effects as populations increase. When effective population size is large, there is a far greater probability of 'fitness enhancing' innovations being maintained and disadvantageous innovations being deleted than when effective population size is small. Therefore, as each techno-unit represents an innovation, small populations can be expected to have less complex toolkits than large populations. Thus, there should be a significant positive correlation between population size and toolkit diversity and complexity (Collard et al., 2005).

Collard et al., (2005) used a stepwise multiple regression analysis and a dataset of 20 hunter-gatherer populations to evaluate the relative importance of four main factors commonly thought to influence the diversity and complexity of stone tool assemblages, 1) the nature of subsistence resources exploited, 2) risk of subsistence resource failure, 3) degree of residential mobility, 4) and population size. They found risk of resource failure has a significant impact on toolkit diversity and complexity, while the nature of subsistence resources exploited, degree of residential mobility, and population size show no significant correlation. However, they do note there are several 'non-conforming' hunter-gatherer populations that disagree with this general model.

2.6 – Potential sources of error

When comparing the lithic assemblages of sites to determine mobility strategies, one major problem arises. This is the problem of temporal continuity, that is, if each site within a region or landscape can be related to a continuous mobility system operated by a single group or culture. This problem is compounded by dating. Is it possible to say a group, 100-200 years apart, is practising exactly the same mobility strategy or at least the same degree of mobility? Several archaeologists, including myself, recognise the importance of understanding mobility strategies as they are extremely fluid, with the presence of elements of both residential and logistical strategies in varying degrees. One site could invariably represent a mobility strategy utilised 100 years before another site within close proximity. One site may be a residential camp used within a more residential strategy where no logistical field camps were constructed, while the other may be a logistical field camp from a logistical strategy. The close proximity of these sites may have the effect of resembling a logistical strategy and masking the earlier residential strategy. Thus, it is important to realise the difficulty in determining whether a tool had hunting or domestic functions. Odell (1981) shows this from the

Mesolithic site of Bergumermeer in the northern Netherlands. Here he found the categories of microlithic points, burins, and backed blades, which correspond to specific techniques of manufacture, appear to be discrete functional units, whereas the formal categories of knives, side-scrapers, end-scrapers, borers and axes, which are less discrete and defined more by elements of retouch, show a level of functional heterogeneity. He argues, due to this, determining function from morphological characteristics alone is not suitable for use in lithic analysis. Evidence from this site suggests artefacts classed as knives and endscrapers were being used as projectile points rather than the use their classification names suggest their respective functions should be. One example was the morphological knife category in which there were more pieces judged to have been projectile points than actual knives. It was found from the wear traces, a large percentage of the knife category appeared to be relatively small in size, and many would have been classified as microlithic points had they been retouched in the appropriate places.

2.7 - Research Methodology

This chapter has so far discussed the many aspects of hunter-gatherer subsistence behaviour, the consequent effects on mobility, and how archaeologists have attempted to witness changes in these behaviours in the stone tool record. To answer the research questions set forward in this thesis, several of these archaeological and ethnological indicators for hunter-gatherer subsistence and mobility behaviour will be combined and utilised to form a general model of expected archaeological signatures for residential and logistical mobility strategies which can then can be applied to the archaeological record of the Pleistocene/Holocene Transition in northwest Europe.

2.7a - Stone Tool Assemblage Indicators

Devising a robust set of indicators to determine changes in mobility from lithic assemblages is a complex and difficult proposition. Firstly, there are the many theories and hypotheses developed from the hunter-gatherer ethnographic record, which are commonly criticised for being both spatial and temporally distant to each other, and to prehistoric populations, and often provide contradictory models which can confuse expectations. Secondly, the archaeological lithic record itself is problematic in that it is difficult to define what constitutes a tool and its function or functions, along with a whole host of problems involving deposition, natural and unnatural disturbances, bias in excavation, excavation and report quality, and availability of data, to name a few.

Here, a set of indicators considered to be suitable to analyse the lithic assemblage data from sites in northwest Europe during the Pleistocene/Holocene transition will be set out based on an amalgamation of the theories and hypotheses discussed. Archaeological indicators will be selected by considering important aspects of hunter-gatherer mobility and tool production, mainly, 1) cost, risk, and anticipation as a selective factor, 2) curation, retouch, and expediency, 3) diversity and complexity, and 4) raw materials.

2.7b - Cost, Risk, and Anticipation

Cost

Cost can be related to a whole array of actions and activities engaged in by hunter-gatherer populations. These include time and energy expended in resource collection and processing, and the net gain from these activities (i.e. does the net gain from collecting and processing a specific resource justify the energy and/or time to exploit it). These examples only consider economic cost and relate directly to group survival. However, there are also social and political costs that are much more difficult to see in the archaeological record. Costs can include group identity, interaction and trade, group territories, religion/beliefs, and tradition. These less quantifiable costs would have an effect on decisions and preferences influencing economic strategies, such as access to good quality raw materials, and tool design choices influenced by group identity and/or tradition.

Risk

Risk is a component of cost, and may be thought of as particularly relevant when determining changes in mobility during climatic events such as the YD. It could be expected a return to stadial conditions in northwest Europe during the YD would have increased the risk involved in successful hunting over the previous and subsequent Allerød and PB interstadials. The shift from more densely concentrated animal and plant resources to open and more highly dispersed and seasonally mobile animals would have undoubtedly influenced hunter-gatherer subsistence strategies. Harsher environments, with less densely populated food resources, would drastically increase the risk and consequences of failure. Thus, it would be logical to assume more specialist and reliable hunting equipment would be a crucial technological adaption in order to mitigate this risk. This has been outlined by Binford (1979; 1980), Torrence (1983; 1989), Myers (1986), amongst others.

Anticipation

Risk can be directly related to anticipation as anticipation can be effective in minimising risk. Anticipation is more complex to visualise, as this is more dependent on the mobility strategy employed than the resources exploited. Binford (1979; 1980) states more residentially mobile populations would have a greater emphasis on anticipation of future events. A residentially mobile group would require thorough understanding of what resources become available at certain times of the year and plan their occupations accordingly. It would be expected a more mobile population would place a greater emphasis on creating more multifunctional toolkits in advance, which can be used for several different activities as they travel. This has led to the theory that more mobile groups will have a greater emphasis on producing more formal, multifunctional, and portable tools (Andrefsky, 1994; 1998). This is in contrast to more logistically mobile populations, who are more sedentary in nature, and would only need to manufacture specialist tools for specialist tasks at pre-determined locations and times nearby a central residential base. Thus, these groups can afford to make these tools less in advance, and closer to the time they are expected to be utilised, leading to many archaeologists (Andrefsky, 1994; 1998; Parry and Kelly, 1987; Torrence, 1989; Young, 1994) to believe more sedentary populations would prioritise producing quickly manufactured, expedient, tools used only for a few specialist activities at certain times of the year.

However, how can we relate anticipation to expectations of climate change and changes in mobility? Binford (1980) has stated a logistical strategy is more likely to be practised during colder climatic phases due to the shorter growing seasons during these periods. In colder climates, it might be tempting to assume pre-planning tool manufacture for future events would be a crucial factor for hunter-gatherer populations living in such conditions. However, pre-planning in logistical populations is related more to what resource will be exploited at which logistical camp and at what time of year. If it is known what kind of activities are to be carried out and at what time, it becomes less necessary to spend extra time investment on tools well in advance. Rather the tools can be manufactured at specific times nearer the expected times of specific resource exploitation.

In more residentially mobile populations, the manufacture of tools in anticipation of several different episodes of resource exploitation in advance, becomes much more important as carrying large amounts of raw material, ready to be utilised at a moment's notice for one specific task, is generally not considered a viable strategy. However, this is reliant on the availability of raw materials in the region. It could be possible that suitable raw materials are easily found throughout the region, and could potentially be simply picked up off the ground when needed. In this case it could be expected an expedient tool manufacturing strategy may also be a viable option. Importantly it should be noted mobility is not the only factor to consider. Quality of available raw materials may also condition the production of expedient versus formal tools. Andrefsky (1994) showed poor raw materials tend to be made into more expedient tools, while good quality raw materials are made into formal tools, but only when good quality raw materials are in low abundance. In areas with plentiful, good quality, raw material, both expedient and formal tools were manufactured. However, his study did not consider the relative proportion of expedient versus formal tools in lithic assemblages. Andrefsky's (1994) findings may be of significance when considering the relation of mobility and tool expediency, and should be noted when forming interpretations based on these assemblage characteristics. However, for the purposes of this study, it will be assumed higher proportions of expedient tools in lithic assemblages should be a general characteristic of logistically mobile populations while higher proportions of formal tools should be a general characteristic of residentially mobile populations. Following this assumption, we should expect to see the following characteristics in the lithic assemblages of residentially mobile versus logistically mobile hunter-gatherer populations (see Table 2.7).

	Residentially Mobile	**Logistically Mobile**	**Archaeological Indicators**
Proportion of expedient tools	Low	High	Number of formal tools/Number of retouched and utilised blanks
Proportion of formal tools	High	Low	Number of formal tools/Number of retouched and utilised blanks
Levels of retouch	High	Low	Number of retouched tools/Total lithic assemblage

(Table 2.7: Predictions of the proportion of expedient tools, formal tools, and levels of retouch in lithic assemblages of residentially and logistically mobile populations)

So how do we see this in the archaeological record of a site? It should be possible to simply compare the expediency of the toolkit from two or more assemblages by measuring the number of utilised blanks compared with recognised formal tools. However, there is nothing to say non-utilised blanks were not also used as tools, in which case comparing the total number of blanks with the number of recognised formal tools may also be wise. The degree of retouch on blanks and tools is extremely subjective and inconsistently recorded in the reports from the sites compiled in this study. However, the basic category of 'retouched' and 'utilised' blades and flakes are consistently reported, at least enough to form reliable comparisons from site to site. Information on core reduction strategies would also be highly useful to determine the efficiency of core processing, i.e. how wasteful was core processing in terms of raw material used for tool manufacture, with wasteful processing a more expedient strategy and more efficient processing a more formal tool strategy. Again, details of core reduction techniques are inconsistently reported if at all, which make this line of enquiry difficult. Table 2.8 and 2.9 show the potential cost, risk and levels of anticipation for common hunter-gatherer activities in residentially and logistically mobile strategies, and the predicted characteristics of lithic assemblages as a response to these factors.

Logistical Mobility

	Cost	**Risk**	**Anticipation**	**Lithic Assemblage Characteristics**
Hunting	High	High	Low	Specialised
Foraging	Low	Low	Low	Generalised?
Tool production	Low	High	Low	Expedient
Tool maintenance	Low	Low	Low	Low retouch
Tool complexity	Low	Low	Low	More complex
Raw material procurement	High	Low	Low	Higher proportion of non-local materials

(Table 2.8: Levels of cost, risk, and anticipation in logistically mobile hunter-gatherer populations and the expected effects on lithic assemblage characteristics)

Residential Mobility

	Cost (energy, time, social)	Risk	Anticipation	Lithic Assemblage Characteristics
Hunting	High	High	High	Generalised
Foraging	Low	Low	Low	Generalised?
Tool production	High	Low	High	Formal
Tool maintenance	High	Low	High	High retouch
Tool complexity	Low	High	Low	Less complex
Raw material procurement	Low	High	High	Higher proportion of non-local materials

(Table 2.9: Levels of cost, risk, and anticipation in residentially mobile hunter-gatherer populations and the expected effects on lithic assemblage characteristics)

2.7c - Curation, Retouch and Expediency

Curation of lithic artefacts can also provide evidence for mobility strategies. Curation here is directly linked to expediency in tool manufacture. A formal tool will be curated and maintained for longer compared with an expedient tool, which is more likely to be readily discarded when used or blunted. This may also include utilised flakes and blades that, in a strategy in which conserving raw materials or anticipating future events is crucial, may need to be curated to last longer. It is hypothesised more mobile population will curate their tools for longer due to the formal nature of their toolset (Andrefsky, 1994) and a more sedentary population would have less need to curate their toolset due its more expedient nature. If this is accepted then it would be expected a residentially mobile population would have a higher level of curation and/or maintenance compared with logistically mobile population. This may be seen in the number of retouched tools and retouched and utilised blanks within an assemblage. Also, the amount of maintenance debris, such as chips, may provide evidence for higher or lower levels of maintenance and thus curation between sites (see Table 2.10).

However, as discussed, there are several problems pertaining to the identification of retouch, along with what constitutes as retouch. This problem also extends to identifying utilised flakes and blades. Another problem arises from the effects of trampling which may give the effect of retouch or use wear (Odell, 2001). Further problems arise when considering the dataset in this study, which provides inconsistent levels of information on retouch and utilisation.

However, utilised and retouched blades and flakes are quite consistently tallied, which provides a method of comparison between sites.

Characteristics of Curation	High Mobility	Low Mobility	Archaeological Indicators
Retouch intensity	High	Low	Number of retouched edges per tool
Maintenance products	High	Low	Numbers of chips Numbers of flakes
Tool forms	Formal	Expedient	Proportion of retouched and utilised blanks versus formal tools

(Table 2.10: Characteristics of curation in high and low mobility hunter-gatherer populations)

Parry and Kerry (1987) found with increasing sedentism, and the decreasing importance of transporting tools, there is a decrease in the proportion of formal tools showing facial thinning, such as projectile points, scrapers and bifaces, suggesting a lesser emphasis on multifunctional tools and a shift to more expedient toolkits. They also found at special task camps there is a higher tool/core ratio, more formal tools and a higher percentage of prepared platforms (see Table 2.11).

Characteristics of Lithic Assemblage	High Mobility	Low Mobility	Special Task Camps
Proportion of formal tools	High	Low	High
Proportion of formal tools showing facial thinning	High	Low	-
Tool/core ratio	High	Low	High
Percentage of prepared platforms	-	-	High

(Table 2.11: Characteristics of expediency in high and low mobility hunter-gatherer populations and in special task camps)

2.7d - Diversity and Complexity

Diversity has been commonly used as an important avenue in lithic analysis since the mid 1980's. The methods for determining diversity in lithic assemblages have sensibly adapted principles employed in archaeological faunal studies, such as measures of richness and evenness. Richness and evenness (as described by Lyman, 2008; Rindos, 1989) are two measures that can tell us a lot about the structure of an assemblage. Richness can provide us with information on the general diversity or variety of tools in a lithic assemblage, while evenness provides information on the relative abundance of each tool within a lithic assemblage. Evenness is a useful measure as, even though there may be several different recognised formal tool types within an assemblage, this does not mean every tool type is an important and/or representative component of that assemblage. The more even the measure of relative abundances of tools are, the more diverse the assemblage. In contrast, an assemblage of which the measure of relative abundance is skewed towards an individual tool, or set of tools, would be seen as less diverse and more specialist. The statistical equations used to measure evenness are presented in section 2.4b of this chapter. These measures are primarily used in the field of faunal studies but can also be adapted to any type of species analysis including lithics. However, as discussed, richness and evenness are particularly susceptible to the effects of sample size. It has been shown the number of types of species encountered in a collection naturally increase as the total number of individuals recovered increase. Considering the sample sizes of lithic assemblages from the northwest European Pleistocene/Holocene transitional sites can vary enormously, from as little as 10 recognised artefacts to as many as 12,000 artefacts. This is a potentially large source of error when comparing sites. Rindos (1989) suggests the simplest method for countering this problem is to either compare collections of equal numbers of individuals from two or more samples, or to compare two or more unequal samples of completely inventoried populations. As discussed, for the purposes of this study, an assumption must be made that the entire lithic assemblage of each site has been fully inventoried, as finding equal sized lithic assemblages from this period is not possible. This is due to a large variation in site functions and occupation length, which in turn leads to a large variation in numbers of deposited lithic artefacts. Additionally, the collection of lithic material from a site is highly dependent on the quality of excavation and the subsequent recording and/or publication of the data.

Shott (1986) and Andrefsky (1994; 1998; 2008) have proposed, in general, as a population becomes more mobile the diversity of tool types decreases. Basically, tool diversity is indirectly proportional to the level of mobility of a population. This is a logical argument, as it is widely believed less mobile logistical populations should use a more specialist toolkit to carry out specific tasks, therefore there should be more formal tool types to carry out several different specific tasks. Conversely, more residentially mobile populations would be expected to have a more generalised toolkit to take advantage of several different tasks when they are encountered while moving from location to location.

So, what are the best methods to determine diversity and complexity in the northwest European Pleistocene/Holocene transitional lithic assemblages? There are several ways to determine diversity, the most simplistic of which would be to count the number of recognised formal tool types and divide that number by the total number of artefacts to produce a relative diversity for each assemblage. However, this method suffers greatly from sample size, a problem which is particularly relevant to the dataset within this study. Alternatively, statistical approaches may offer a more insightful view into aspects of assemblage diversity, such as the Shannon Index and the Simpson Index.

Another proposed measure of diversity comes from the assumption higher density assemblages would contain a higher diversity of tool types (Jones et al., 1989). This assumption is based on the principle residential sites are typically expected to have the greatest diversity of activities carried out on site, and would have been a base for tool manufacture and/or maintenance. This would create a larger density of lithic debris from a larger range of activities when compared with specialist-task camps, which would have smaller lithic assemblages possibly from tool repair, discard, or loss. Additionally, residential camps would be expected to have a higher population size compared with special-task camps, which would also imply there should be a higher density of artefacts at residential camps. To calculate density, it may be possible to simply divide the number of lithic artefacts by the size of the site either in m^2, or ideally in m^3. Measuring density relies on the assumption all artefacts represented within an assemblage have stayed more-or-less in situ and not been spread out over a large distance or collected together by natural (or unnatural) phenomena. However, in the dataset compiled within this study, site size is inconsistently documented and the few reported site dimensions are usually in surface area rather than volume of soil. Due to this it is proposed, in the absence of consistent size dimensions, the total number of artefacts be used as an additional indicator for density. This assumption is based simplistically on the idea a site with a larger amount of material would belong to a larger site containing a higher amount of activities. This eliminates, to some extent, the problem of artefact movement, implying all or most artefacts have been collected from a site, but has the resulting problem of assuming a large number of lithic artefacts are not deposited over a large area, or a small number deposited in a small area. There should also be the further expectation sites operating within a logistically mobile system would have a much higher variation in density from site to site, representing the mixture of residential base camps and special-task camps. In contrast, it would be expected, in a residentially mobile system, artefact density should be more uniform from site to site, representing the dominance of residential base camps within this strategy. Another potential indicator of site type and function would be to distinguish between domestic and hunting tools. A site with a high proportion of domestic debris from manufacture and maintenance would most likely be a residential area or base camp. In contrast, a site with a lower proportion of lithic debris and a higher proportion of extractive or hunting tools would most likely be a special-task or limited activity camp. Consequently, it might be possible to define residential camps by indicators such as the large amounts of chips and small flakes.

Complexity is another important technological adaptation that, along with diversity, can significantly decrease risk and increase efficiency of specific activities. Myers (1989), proposes increasing quantity and types of microliths from the Early to Late Mesolithic Britain is a response to increased time-stress and hunting risk. This is further supported by the reported lack of bone and antler harpoons, seen in the Late Mesolithic, compared with the previous Early Mesolithic. Myers (1984) proposes microliths should be seen as a replacement for bone and antler harpoon barbs and the increase in types of microliths may be seen as an increase in complexity by producing more flexible and maintainable weapons. Bone and antler harpoons would be a lot less flexible and repairing broken barbs would be near impossible without having to manufacture a whole new harpoon with all the processes of raw material procurement and steps in manufacture. This would make bone and antler harpoons unsuitable in highly time-stressed and risky hunting strategies. Even though microliths should not be directly linked to the technological replacement and redundancy of harpoon barbs on bone and antler harpoons, the shift away from these tools to alternative microlithic tools, which would have no doubt been more flexible and maintainable, suggesting there was an accompanying shift to more time-stressed activities from the Early to Late Mesolithic in the Britain. Thus, increases in microlithic components within a lithic assemblage may suggest an increase in complexity in response to an increase in time-stressed activities. It is proposed here the proportion of microliths, along with the number of different types of microliths, may be one possible measure that can be employed to determine toolkit complexity. Also, the presence or lack of bone and antler harpoons, although not lithic based, may suggest more, or less, complex toolkits. The expected characteristics of diversity and complexity within a lithic assemblage in high mobility versus low mobility populations are set out in Table 2.12.

Characteristics of Diversity and Complexity	High Mobility	Low Mobility	Archaeological Indicators
Diversity of tool types	Low	High	Numbers of different tool types
Evenness	High	Low	Spread of tool types within an assemblage
Richness	Low	High	Numbers of different tool types
Density of assemblages	High	Low in residential camps, high in base camps	Artefacts per m^2/m^3 , in the case of this study possibly simply No. artefacts
Number of tool components (Complexity)	Low	High	Proportion of microliths in an assemblage

(Table 2.12: Characteristics of diversity and complexity in high and low mobility hunter-gatherer populations)

2.7e - Raw materials

It has been shown raw materials also play an important part in determining hunter-gatherer choices in mobility strategy and tool manufacture. However, raw materials can confuse matters when it is understood the quality and/or availability of raw materials in any one landscape is highly variable from region to region, and can substantially change the composition of stone tool assemblages. This can have the effect of giving the appearance of having been occupied by a highly mobile group when in fact it was occupied by a more sedentary group, with limited access to suitable raw materials. To further complicate matters, limited access may also refer to socially constructed access by sedentary groups who maintain 'ownership' of suitable raw materials in their territories. This may have similar effects on stone tool assemblage composition as natural poor raw material availability and can be difficult to distinguish.

If we assume raw materials are in ready supply and of suitable quality, what characteristics can be predicted for highly mobile populations and more sedentary populations? Firstly, variability of stone raw materials should increase with increased mobility. As a population becomes more residentially mobile it will cover larger territorial ranges more frequently, and likely procure stone raw materials from various different sources. This will also have the effect of having a higher proportion of non-local raw materials in an assemblage belonging to a highly mobile population. In contrast, more sedentary populations, such as logistically mobile populations, move significantly less frequently within a year (although the territory covered may be similar to residentially mobile groups, but moving less frequently). Thus, sites belonging to logistically mobile populations, should exhibit less variability in stone raw materials as the majority of supply will come from a limited, and most likely consistent, number of locations, either nearby or at an easily reached distance. This should also have the effect of logistical sites having a higher proportion of local lithic raw materials.

The distance from raw material sources can also affect the characteristics of a lithic assemblage. It has been shown (Odell, 2000; 2001; 2004), as distance increases, blank/core ratio increases, and flake/tool ratio decreases. This is due to higher intensity in core reduction and a higher proportion of available blanks being modified into tools as a result of a population being unable to procure suitable raw materials immediately. Cores, tools, and blanks are also shorter in length, again due to the intensive reduction of cores, and there is an increase in application and intensity of retouch as a result of maintenance and extended curation while at a distance from a raw material source.

Considering this, it might be possible to link highly residentially mobile populations with populations at increased distance from a raw material source. As a residentially mobile group will move around a landscape more frequently than a logistical group, it would be logical to assume, at several times throughout the year, a group will be far away from a suitable stone source. This would lead to a higher incidence of the assemblage characteristics of a population at increased distance from a raw material source (listed in Table 2.4) in their lithic assemblages. In contrast, logistically mobile groups, who move around the landscape less frequently (possibly season to season), would likely keep a short distance from their base camp to stone sources. This assumption would suggest the lithic assemblages of logistical groups would have the characteristics of a population closer to a stone raw material source. Of course, this is highly dependent on the availability and distribution of stone raw material sources in a landscape, but, if it is assumed suitable raw materials for stone tool production are unevenly distributed in a landscape, at highly variable distances, this may hold true. However, naturally limited suitable stone raw material sources may also produce similar assemblage characteristics both in residentially and logistically mobile populations. Also, more densely populated, semi-sedentary populations may have problems with limited access to suitable stone sources due to their location in the territory of different hunter-gatherer groups. If this is the case, characteristics of lithic assemblages at a distance from stone sources may also be present in groups with limited access to stone raw materials, either in a residentially or logistically mobile population. The use of these assemblage characteristics in this study will be under the strict assumption that suitable quality stone raw materials are unevenly distributed across a landscape, and are openly accessible to all hunter-gatherer groups.

How can we see raw material usage indicators in the archaeological record of the sites in this study? Raw material variability and raw material types are inconsistently reported/published, but several sites do list them amongst lithic assemblage descriptions. Local versus non-local raw material is consistently described in reports and should be able to be used as an indicator. Lengths of cores, tools, and blanks are again inconsistently recorded but there remain a few well documented case studies which may offer interesting comparative analyses. Economy/efficiency of raw material use might be seen from the proportion of blanks compared with cores. This of course depends on the amount each core is reduced. However, this information is rarely reported within the assemblage descriptions compiled in this study, and it will be assumed the less cores per blanks, the more efficient the strategy, while a higher core to blank ratio would suggest more wastage of raw material. Quality of raw material is quite consistently reported (at least in terms of poor vs good quality) so this may represent an opportunity to determine the production of formal and expedient technologies in relation to the available raw material. This can be further related to a site's level of residential or logistical organisation to ascertain if Andrefsky's (1994) proposal of effects on raw material quality and mode of tool production holds true. A summary of expected characteristics can be seen in Tables 2.13 and 2.14.

Raw Material Characteristics	High Mobility	Low Mobility	Archaeological Indicators
Percentage of non-local	Higher	Lower	Percentage of non-local raw materials
Percentage of local	Lower	Higher	Percentage of local raw materials
Disparate/low quality sources	Production of formal tools	Production of expedient tools	Proportion of formal tools vs expedient tools
Easily available/high quality sources	Production of formal tools	Production of formal tools	Proportion of formal tools vs expedient tools
Economy of use	Highly economical	Wasteful	Number of cores/number of blanks

(Table 2.13: Expected raw material characteristics in high and low mobility hunter-gatherer populations)

Lithic Assemblage Characteristics	Increased distance from raw material source	Decreased distance from raw material source	Expected Characteristics in Residentially Mobile Sites	Expected Characteristics in Logistically Mobile Sites
Blank:Core Ratio	Higher	Lower	Higher	Lower
Flake:Tool Ratio	Lower	Higher	Lower	Higher
Percentage of Cortical Flakes	Lower	Higher	Lower	Higher
Average length of primary elements	Shorter	Longer	Shorter	Longer
Average length of formal tools	Shorter	Longer	Shorter	Longer
Blade core facets	Shorter	Longer	Shorter	Longer
Retouch on tools	More	Less	More	Less
Percentage of bifacial thinning flakes	Higher	Lower	Higher	Lower

(Table 2.14: Characteristics of lithic assemblages with increased and decreased distance from raw material source and the expected relationship to residentially and logistically mobile lithic assemblages assuming equal distance and availability of raw materials)

2.7f - General Characteristics of Hunter-Gatherer Camp Types

Finally, it is important to note, when considering lithic assemblages from logistically and residentially mobile populations, the ‘base camp’ is a shared site type between the two systems. The presence of ‘special task camps’ are the major determining factor when recognising logistical systems. Table 2.15 and 2.16 set out the general expected characteristics of the lithic assemblages of base camps and special task camps respectively.

Base Camps

	Incidence	**Archaeological Indicator**
Number of blanks	High	Number of blanks
Number of chips/maintenance products	High	Number of chips and/or flakes
Tool production products	High	Number of production products
Number of cores	High	Number of cores
Number of domestic tools	High	Scrapers, borers, burins etc.
Number of hunting tools	Low/Medium	Points, Microliths
Size of site	Large	Site size in m^2
Density of artefacts	High	Density of artefacts in m^2 or m^3, possibly total number of artefacts
Site numbers	Low	C14 dates as proxies for sites

(Table 2.15: Characteristics of lithic assemblages in hunter-gatherer base camps seen both in logistically and residentially mobile populations)

Special Task Camps

	Incidence	Archaeological Indicator
Number of flakes	Low	Number of blanks
Number of chips/maintenance products	Low	Number of chips and/or flakes
Tool production products	Low	Number of production products
Number of cores	Low	Number of cores
Number of domestic tools	Low	Scrapers, borers, burins etc.
Number of hunting tools	High	Points, Microliths
Size of site	Small	Site size in m^2
Density of artefacts	Low	Density of artefacts in m^2 or m^3, possibly total number of artefacts
Site numbers	High	C14 dates as proxies for sites

(Table 2.16: Characteristics of lithic assemblages in hunter-gatherer special task camps seen only in logistically mobile populations)

2.8 - Concluding Remarks

This chapter has discussed at length the complex issues encountered when trying to ascertain hunter-gatherer mobility from their toolkits in prehistoric contexts and provided a set of potential indicators in which to analyse mobility from lithic assemblages. The following Chapter 3 will evaluate the raw data collected for this study to ascertain sources of error and to minimise them in my analysis. Chapters 4 and 5 will then employ the predicted indicators outlined within this chapter to ascertain how hunter-gatherer populations changed their mobility strategies in the face of the dramatic climate downturn of the YD.

Chapter 3: Examination and Evaluation of Assemblage Data

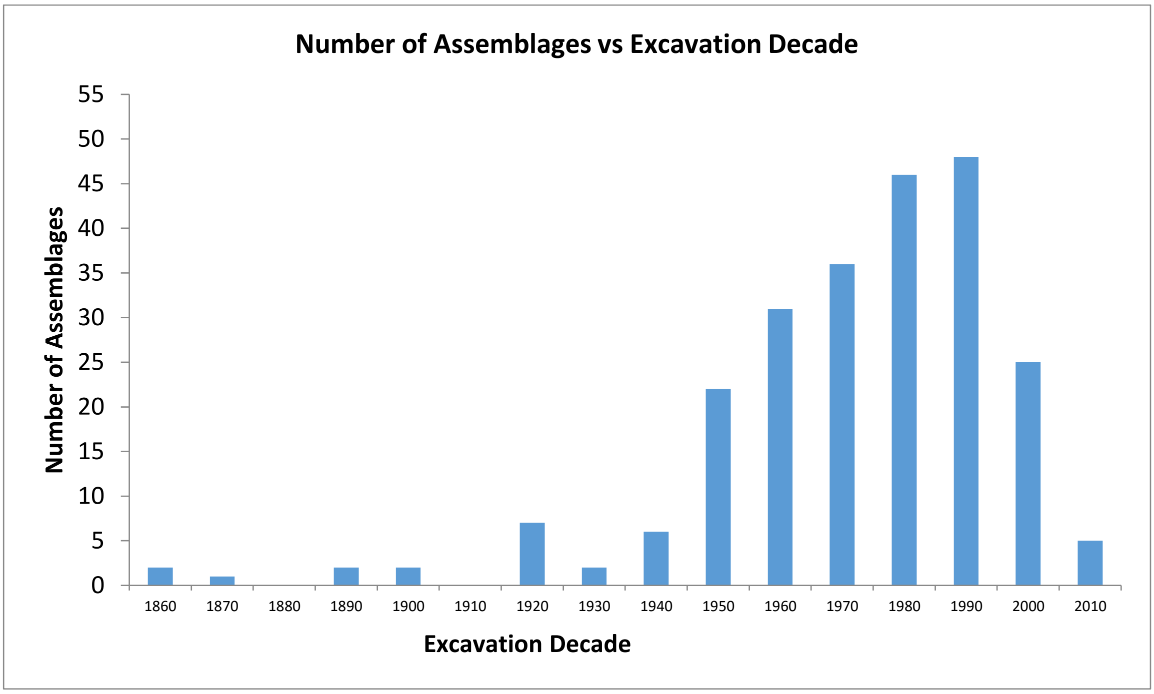
3.1 - Introduction

Before analysing the collected data and interpreting potential patterns in hunter-gatherer mobility related to climate change, it is important to evaluate the composition of the database in terms of the excavation, publication, and presentation of the individual sites that were collected. The quality of archaeological excavation, reporting and publication is well known and accepted to be highly variable through time, from the earliest amateur antiquarian excavations to modern-day professional excavations. This variation over time poses a problem, as it could lead to significant errors when comparing large databases of site and assemblage data belonging to different periods of archaeological research. By recognising and accepting the inevitable flaws and biases within this dataset, one can more reliably analyse the data available, along with advising caution when forming interpretations of trends and patterns. This section will highlight and discuss the possible sources of error within the database presented in this study in an attempt to mitigate such sources, and enable a balanced presentation and interpretation of the results in the following chapters. Many of the following figures include the natural log (Ln) of artefact numbers, area, and altitude, in order to clearly show potential relationships. This would otherwise be confusing due to the overlap of hundreds of data points. A logarithmic scale can be found in Appendix 1, pg. 303 which gives an approximate conversion of Ln numbers to actual numbers.

3.2 - Excavation Date and Assemblage Numbers

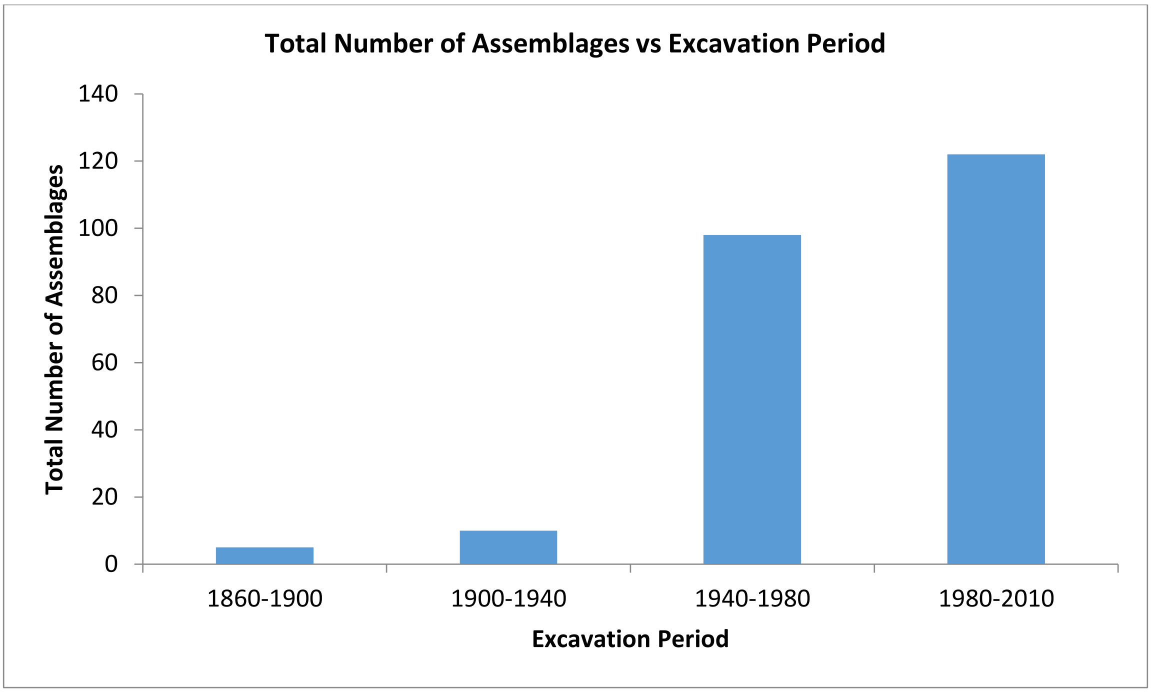
It is well known that our knowledge of what constitutes a well excavated, published, and presented archaeological site has changed and improved over time, along with other factors such as what is considered an artefact, and what artefacts are considered important to record, analyse and present. Thus, it would be expected, for example, sites which were excavated and published in the 1800's would be of lower quality compared with those excavated and published in the 2010's. However, this is not to say that all current excavations and publications of excavations are executed flawlessly today, rather they are more uniformly excavated and published to an accepted standard and have the benefit of modern technologies in both excavation and analysis (and to some extent publication and presentation).

As can be seen from Fig 3.1 the majority of assemblages within the studied database were excavated post-war from the 1950's onward. It is interesting to note the lack of sites excavated so far in the current decade, possibly relating to ongoing analysis of materials which has delayed publication of the results.



(Fig 3.1: Number of Assemblages within the database against the decade of excavation)

This would indicate that, in general, the composition of the database is fairly recent in nature, with a substantial number of sites being excavated in the 1980's and 1990's. Fig 3.2 shows this more clearly when the data is divided into four distinct periods.

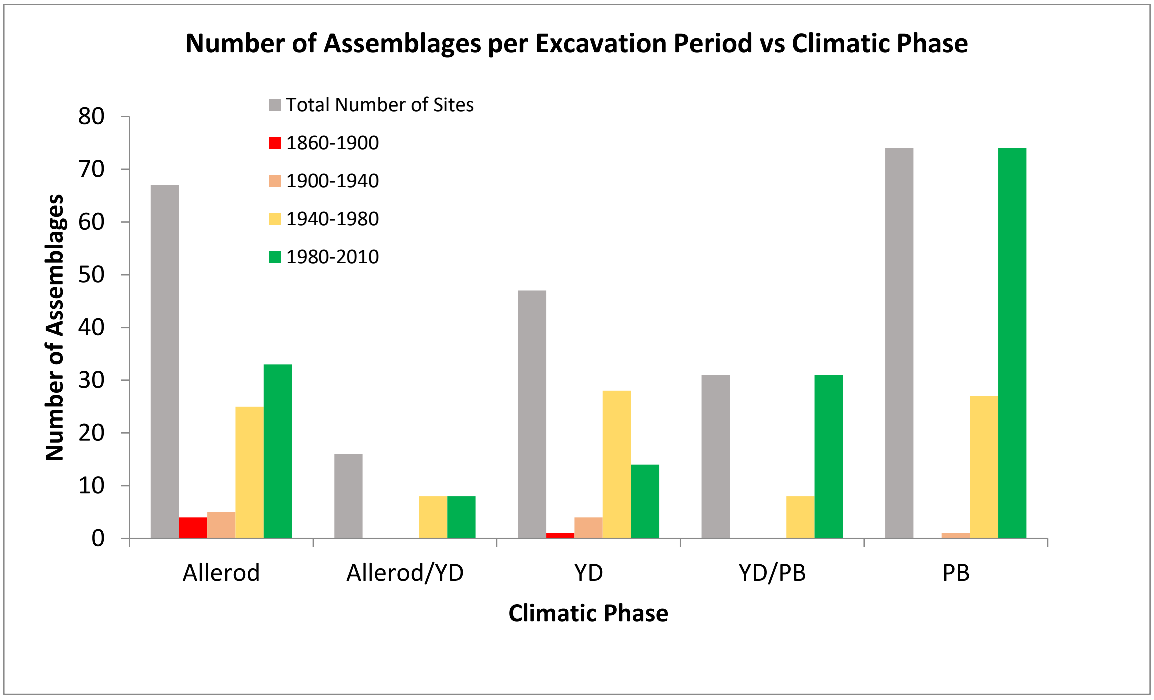


(Fig 3.2: Total number of assemblages against excavation period (defined in text))

However, does this distribution change for each of the climatic phases that are at the centre of this study? Fig 3.3 shows the number of sites by the excavation period for each of the climatic phases; the Allerød, Allerød/YD transition, YD, YD/PB, and PB.

Only the Allerød sites follow the same distribution as the total number of sites, and is the period in which the most sites were excavated from 1860-1940. The YD follows with the second highest number of excavated sites. Interestingly here, there are significantly less sites excavated in the decades from 1980-2010, when compared with the other climatic phases. In comparison, the PB has a significantly high number of sites excavated in the decades from 1980-2010 and only one site excavated in the decades from 1900-1940. The transitional phases of the Allerød/YD and PB/YD consist solely of sites excavated in the decades from 1940-2010, with the YD/PB having a much higher proportion of sites excavated in the decades from 1980-2010.

However, the general trend from climatic phase to climatic phase, is that the majority of sites have been excavated in the decades from 1980-2010, with the notable exception of the YD, in which the majority were excavated in the decades from 1940-1980. This is somewhat surprising as it was assumed there was a general increasing interest in sites attributed to the YD in more recent times, as is the case in southern Europe. This has either not been the case in north-western Europe, or there are many sites from this period currently being analysed and awaiting publication.

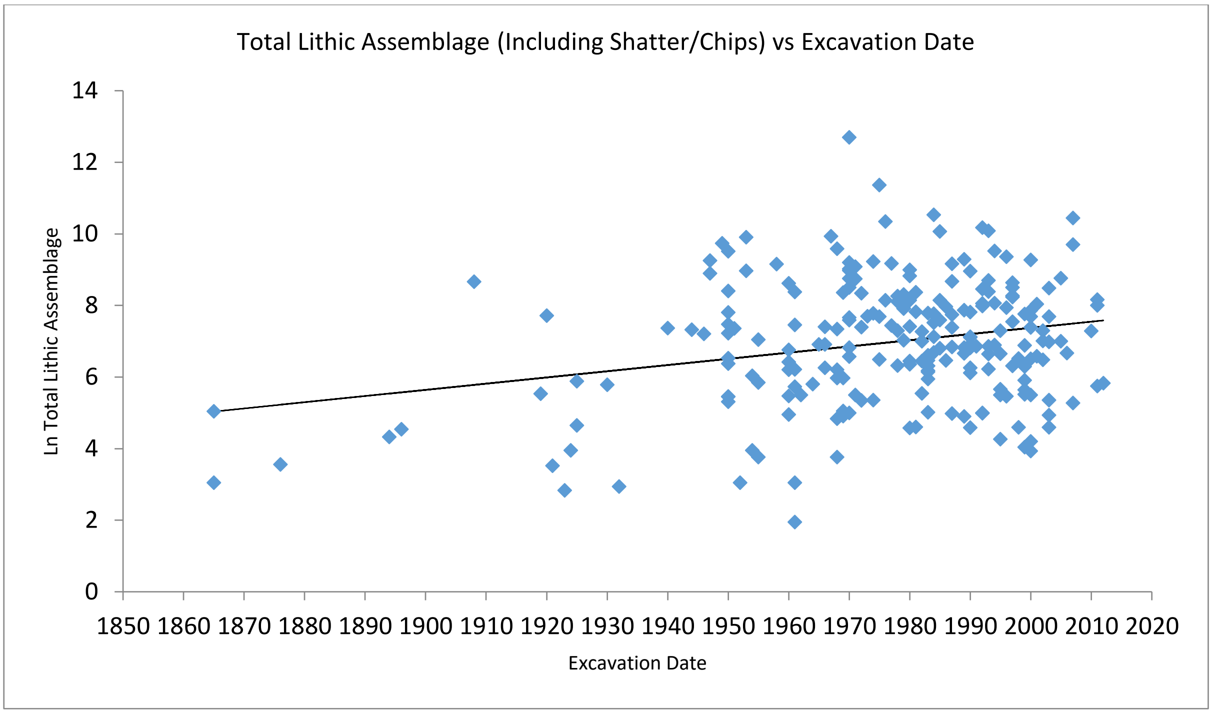


(Fig 3.3: Number of assemblages per excavation period in each climatic phase including total number of sites within the whole dataset in each climate phase)

Overall, in regards to excavation dates, the majority of sites were excavated in the post-war periods from 1940-2010, with a large proportion excavated between 1980 and 2010. In fact, the decades from 1980-2010 represented the highest number of excavations in all but the YD sample. Due to this, the composition of this dataset can be seen as including significantly higher numbers of more reliably excavated and reported sites. Consequently, it is expected there will be minimal effects of excavation quality, relating to excavation date, on the results presented.

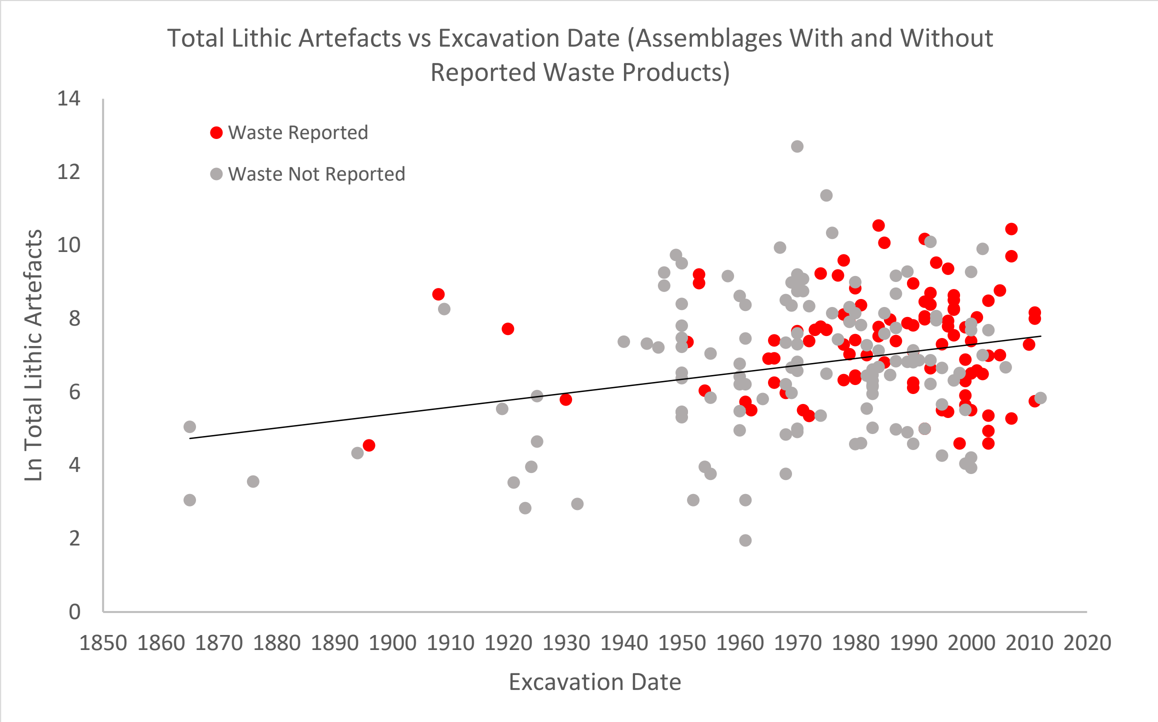
<u>3.2a - Relationship between Excavation Dates and the Numbers of Tools, Blanks, Cores, and Total Number of Lithic Artefacts</u>

We have seen the relationship between excavation date and number of sites, but is there any significant relationship between excavation date and the composition of lithic inventories?



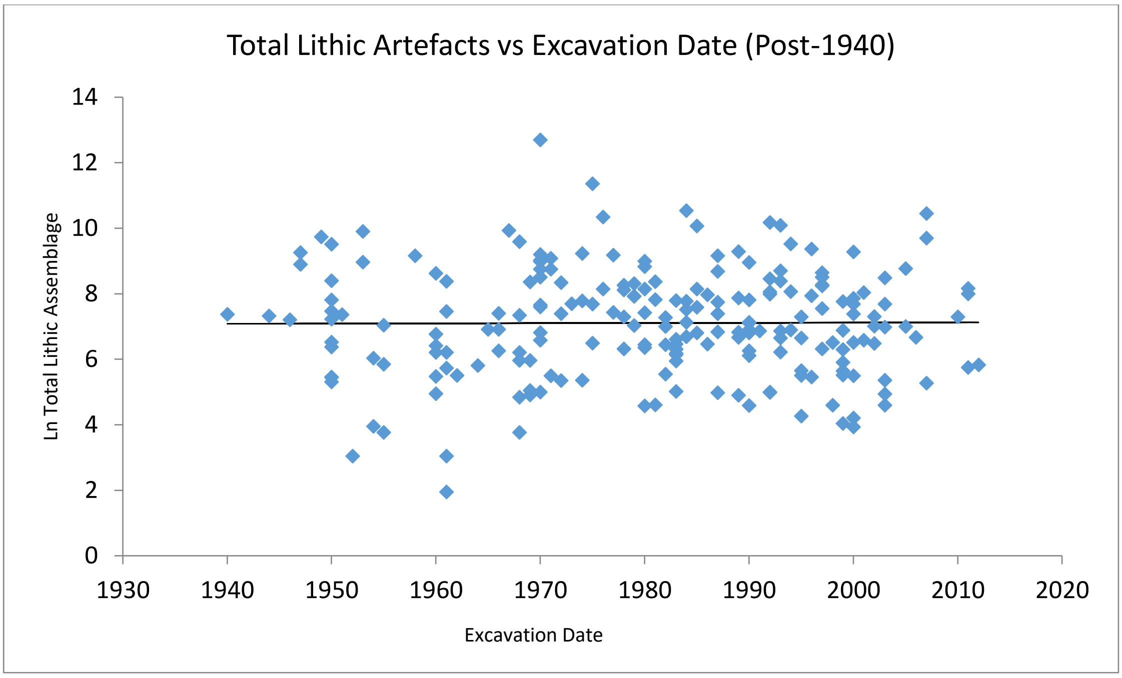
(Fig 3.4: Total lithic assemblage including waste material, against excavation date)

The total number of lithics (including waste material) does not appear to be strongly correlated with excavation date (R = 0.248; p = 0.002), but there remains a significant, weak correlation (Fig 3.4). However, there is a lack of consistent reporting of waste material such as scatter, and chips, especially from excavations prior to the 1940's, but there are still a significant number of sites in which waste material is still not recorded/reported in more modern excavations. Fig 3.5 shows the changes in excavation practices through time regarding the collection and recording of lithic waste products and their perceived importance in archaeological interpretations. This plot indicates any interpretations using lithic waste material in this study should be viewed with caution. It is suggested, here, that waste materials, such as shatter and chips, be excluded from the total artefact counts in order to increase reliability while maintaining sample size.



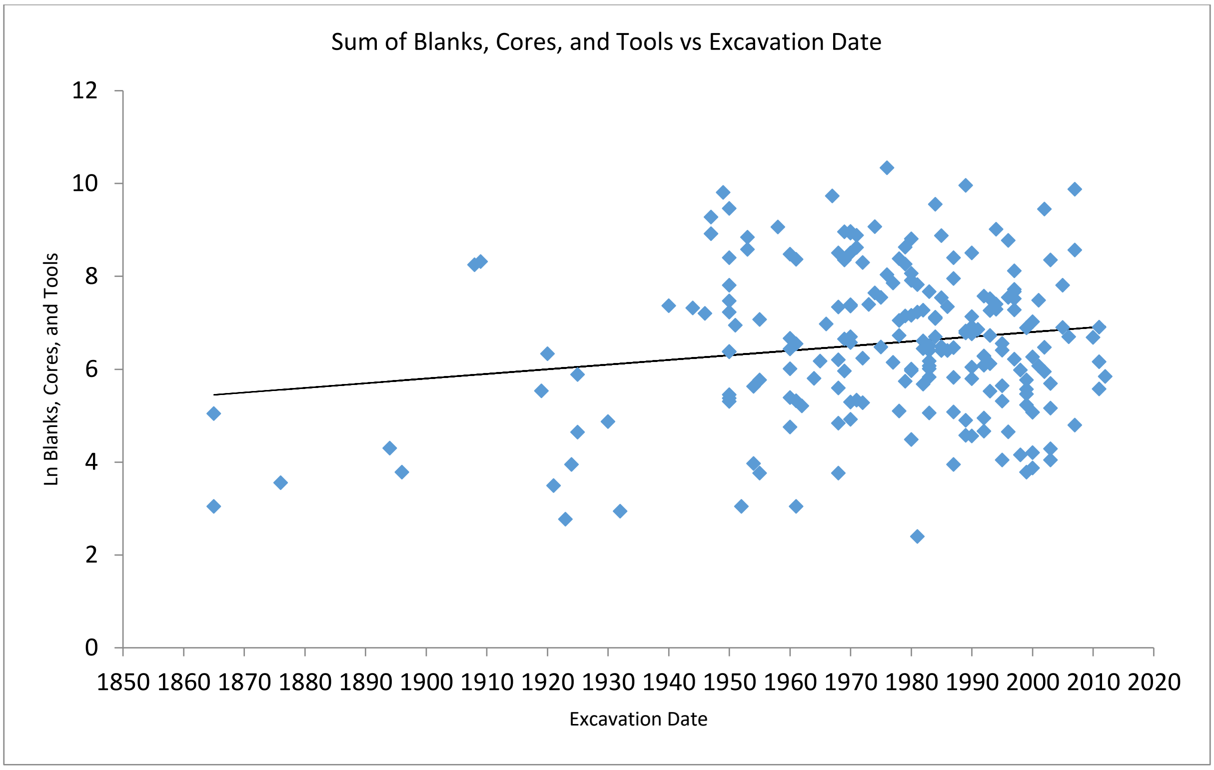
(Fig 3.5: Total lithic artefacts against excavation dates and assemblages with and without reported waste products shatter and debitage)

One possible solution to help mitigate this potential bias would be to exclude all data from sites excavated from older, less reliable excavations at the cost of a slight decrease in sample size. To this end, Fig 3.6 shows the same comparison but with the omission of sites excavated pre-1940's, showing a clear difference, from a quite pronounced positive correlation in the previous full dataset plot (Fig 3.5), to an almost neutral correlation when pre-1940's excavated sites are excluded ($R = 0.006$; $p = 0.648$) (Fig 3.6). Therefore, it can be reliably assumed that the reporting of waste material after 1940 would not have a significant effect on the results.

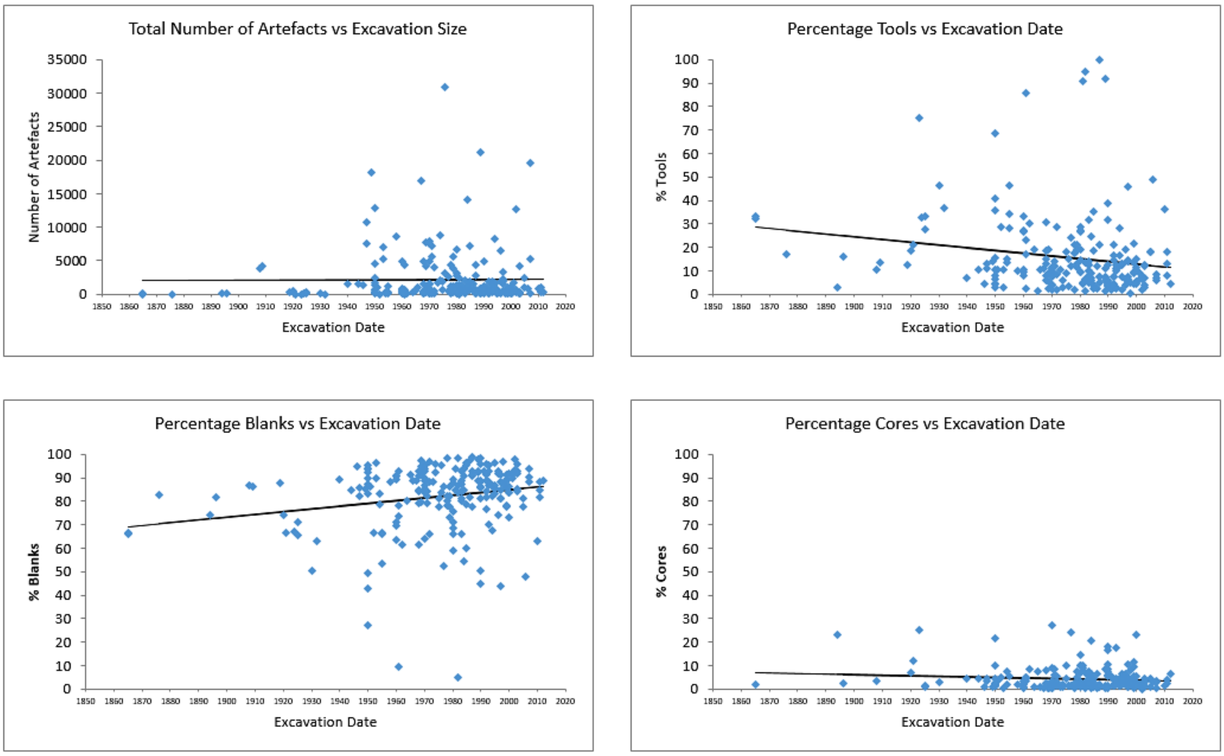


(Fig 3.6: Total lithic assemblage against excavation date excluding excavations pre-1940)

An alternative strategy, to counter the bias, and enable the use of more data, is to use the total sum of the blanks, tools, and cores in each assemblage only, and then using this as a proxy for assemblage size (Fig 3.7). This also shows a non-significant correlation between the total lithic assemblage and excavation date ($R = 0.161$; $p = 0.111$) and suggests that any interpretations based on this proxy for the total lithic assemblage at sites can be seen as reliable. This will be the preferred method going forward in this study, as it maximises sample size.



(Fig 3.7: Sum of blanks, tools, and cores against excavation date)

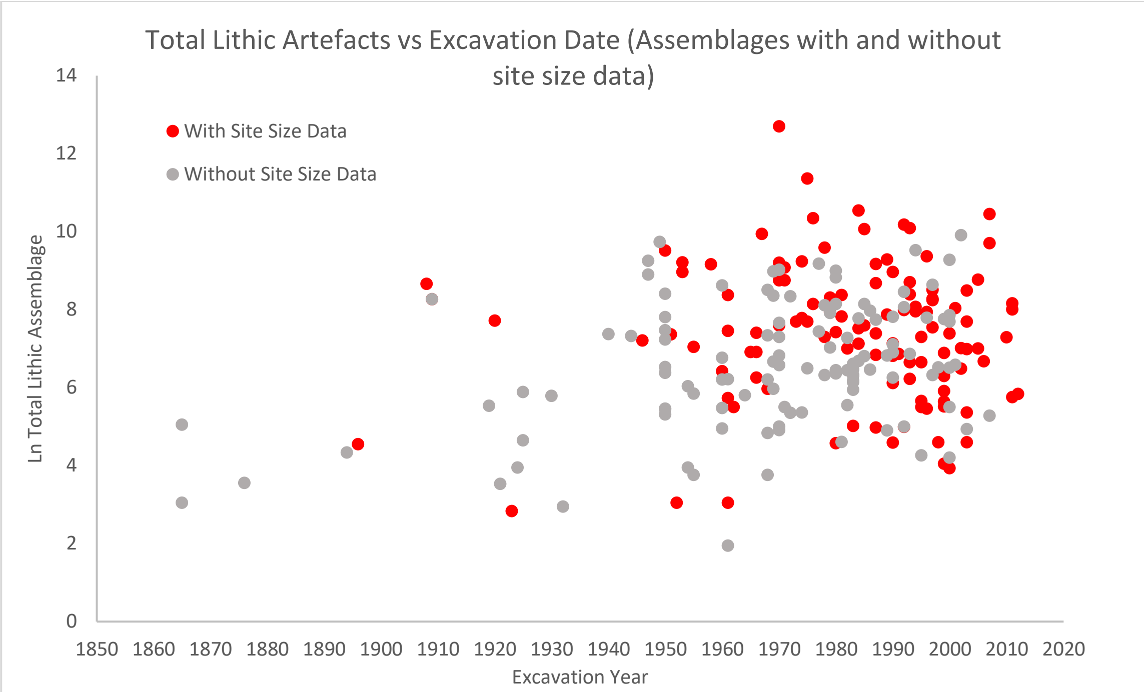


(Fig 3.8: Total number of artefacts, and the percentage composition of tools, blanks, and cores against excavation date)

Fig 3.8 shows the total number of artefacts (excluding waste) and the percentage of tools, blanks, and cores, from sites excavated from 1860 to 2016. It can be seen there is no significant difference in the total number of artefacts excluding waste materials ($R = 0.004$; $p = 0.960$) with excavation date, although it is clear there is a much larger variation in total artefacts recovered from ca. 1950 onward, with much larger assemblages being recorded. As one might expect, there is a negative correlation in the percentage of tools reported in assemblages, possibly representing the reporting of more lithic elements in newer excavations, and is supported by the positive correlation in the percentage of blanks reported. However, there is a weak correlation in both the percentage tools ($R = 0.181$; $p = 0.005$) and percentage blanks ($R = 0.207$; $p = 0.051$), providing no strong evidence that excavation date would drive results. There is a slight negative correlation in the percentage of cores reported, which is again not statistically significant ($R = 0.107$; $p = 0.101$), that might support that reporting of elements has not differed significantly over time, at least not enough to be driving the results of this study, suggesting any interpretations based on the numbers of these artefact types can be assumed to be reliable.

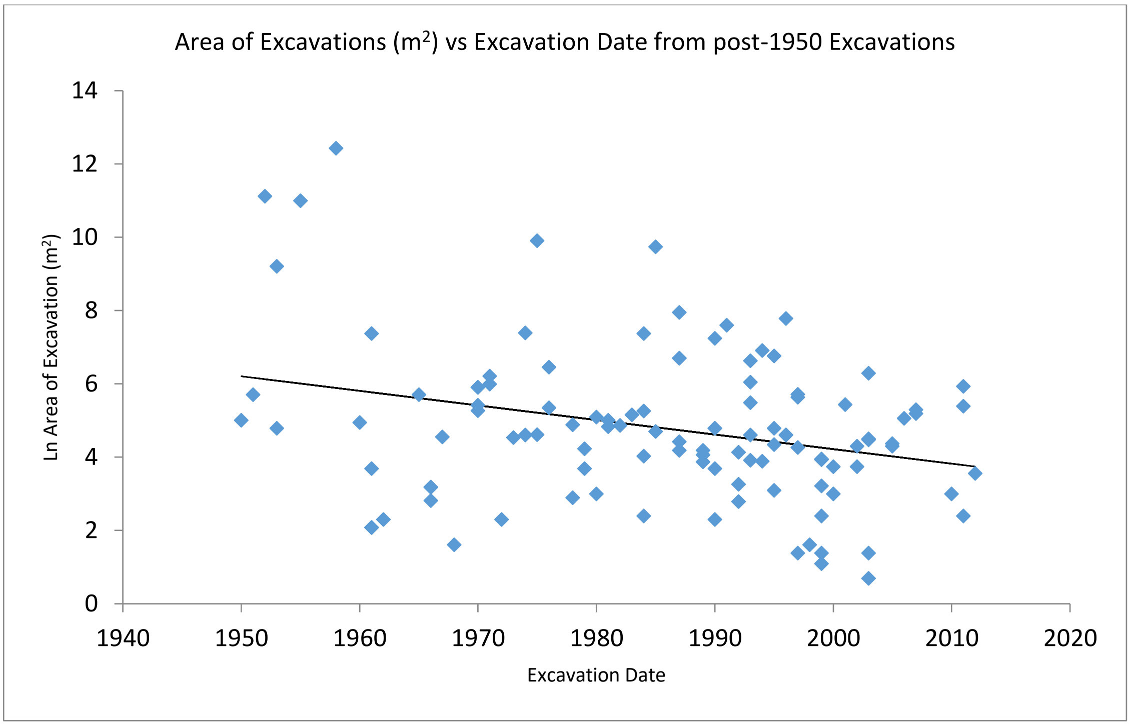
3.2b - Site/Excavation Size and Excavation Date

A relationship between site size and excavation date was also considered as a possible factor for driving results, and any further interpretations relating to numbers of artefacts excavated and recorded. However, sites with site size data are mainly restricted to more modern excavations in this dataset post-1950 (Fig 3.9). Consequently, only post-1950 sites will be tested.



(Fig 3.9: Total lithic assemblage against excavation date, and assemblages with and without site size data)

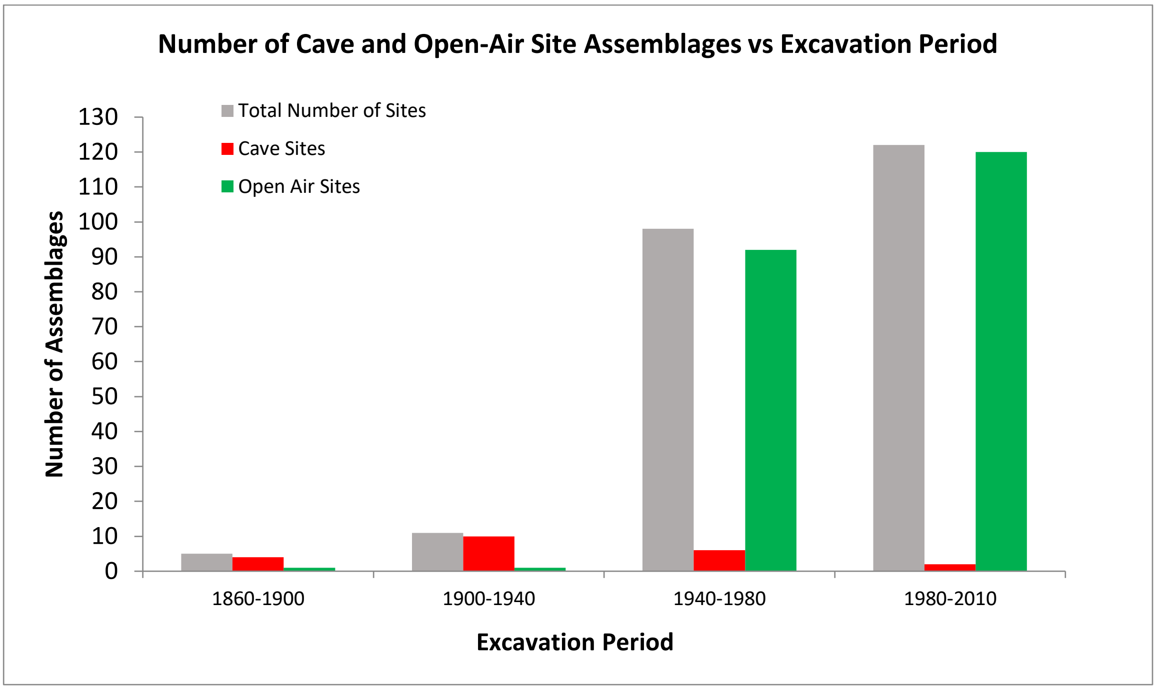
Fig 3.10, shows how site and/or excavation size relates to excavation date from excavations post-1950. Somewhat surprisingly there is a statistically significant, although weak, negative correlation ($R = 0.298$; $p = 0.001$) between site size and excavation date. There seem to be a higher number of smaller size sites and/or excavations from around 1990 to the present day, with the distinctly larger excavations being carried out in the 1950's. This may be a factor of the increasing numbers of rescue excavations, which target smaller areas over shorter periods of time in more recent times. This implies, sites excavated more recently tend to be smaller in size which, when comparing site and/or excavation size, may affect results for specific climatic phases if any one of the said phases has a predominance of recent or older excavations.



(Fig 3.10: Area of excavation in m^2 against excavation date using data from post-1950 excavations only using the total lithic assemblage including waste products, R =0.298; p = 0.001)

3.2c - Site Type and Excavation Dates

Along with the general question of when sites were excavated, it would also be wise to look at the relationship between site excavation dates and the type of site excavated. Fig 3.11 shows the number of cave and open-air sites from each excavation period that have lithic assemblages suitable to analyse and compare. It is important to note that this data does not include the actual numbers of cave and open-air sites from each excavation period that have human and/or humanly modified organic remains and sites with poor lithic assemblages not suitable for analysis and comparison. In general, there are very few cave sites represented in this dataset, especially in comparison with open air sites which dominate post-1940's excavations. Interestingly, out of the 22 cave sites with robust lithic assemblages that have excavation dates recorded, 14 of them were excavated pre-1940 and only 2 post-1980, the other 6 falling in the decades from 1940-1980. There are also a very low number of open-air sites comparable with the number of cave sites for the same period (pre-1940's). In addition, it is interesting to note that the majority of cave sites with robust lithic assemblages are found in the UK (13) and Belgium (6). This suggests there is a bias in the data towards cave sites in excavations dated to pre-1940 which may affect the numbers of artefacts recorded through time. It could be rightly argued, depending on whether the site was a cave site or an open-air site, there may be different organisational uses by hunter-gatherer populations, which might result in a natural difference in artefact composition between the two site types. As there is a bias towards cave sites in earlier excavations, and open-air sites in more recent excavations, could this lead to deceptive correlation between total numbers of artefacts and excavation date through time?

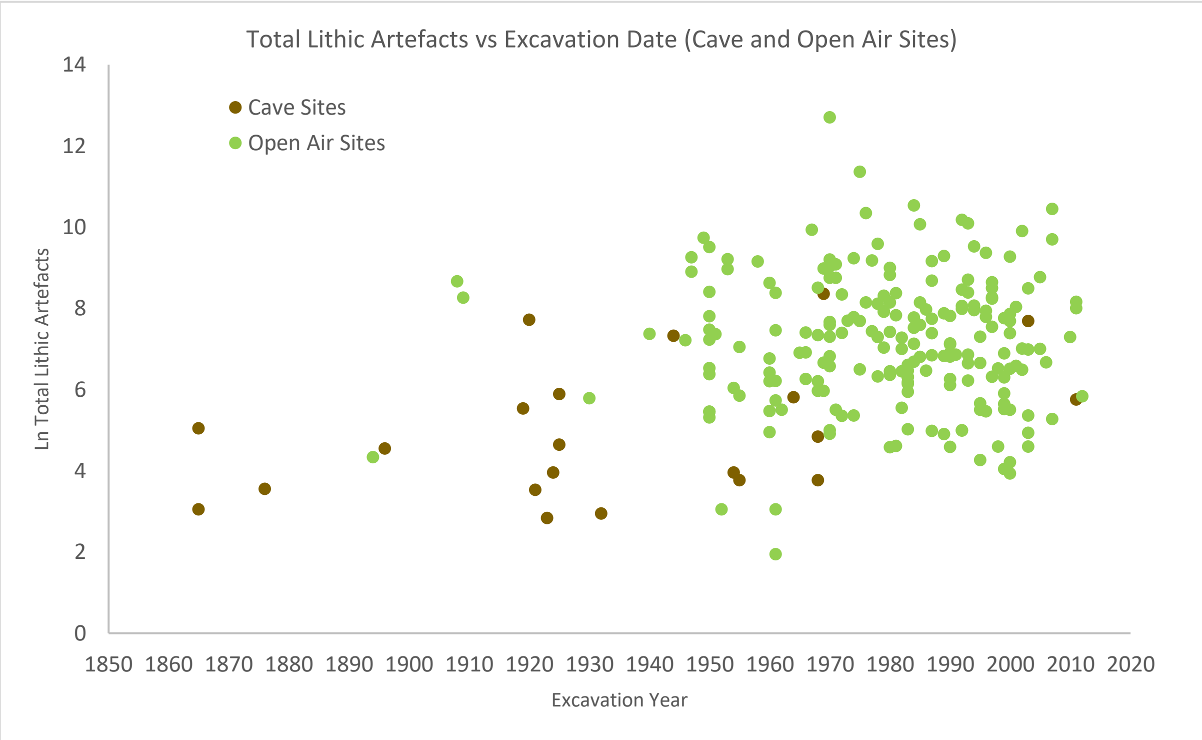


(Fig 3.11: Number of cave and open-air site lithic assemblages against the excavation period)

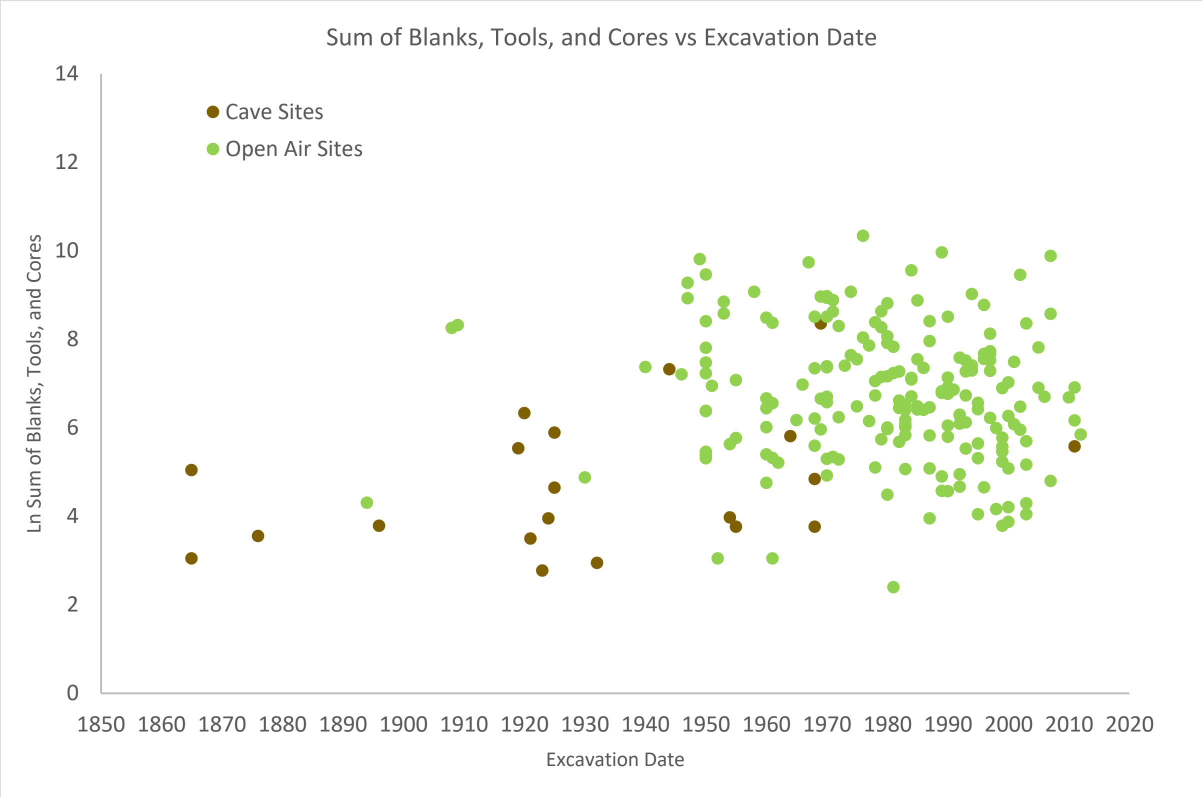
Fig 3.12 shows the excavation dates, total number of artefacts, and the site type. The cave sites are distributed strongly around pre-1940 excavations and have generally lower assemblage sizes. However, as previously noted, earlier excavations are less likely to report data such as number of shatter/chips and blanks, which may be initially deceiving. Perhaps if waste material was reliably and fully reported in earlier excavations the assemblage sizes would resemble those of more modern excavations. However, the more recently excavated cave sites do not seem to have significantly higher numbers of artefacts than earlier excavations. Does this imply that cave sites produce less waste material compared with open-air sites? It is impossible to resolve this problem due to the lack of open-air sites in earlier excavations. However, the few open-air sites pre-1940 again seem to show no remarkable difference in total number of artefacts than many of the more recent excavations. This again raises the question, if the generally lower number of artefacts in earlier excavations may be an important component of hunter-gatherer cave use, rather than poor recording of "waste" artefacts.

As can be seen in Fig 3.13, when waste material is excluded, there appears to be no significant difference in the relationship between the numbers of lithic artefacts in cave and open-air sites between early and modern excavations compared with Fig 3.12. However, it is interesting to note the number of lithic artefacts from the majority of cave sites do not appear to change significantly, possibly indicating cave sites have less lithic waste products due to hunter-gatherer behaviour rather than poorer excavation techniques, and thus explaining why waste is reported less in the earlier excavations.

Open-air sites dominate post-1950 excavations with lithic assemblages, where there is a sharp and marked increase in both the total number of sites and the number of open-air sites. There are only 8 cave sites with good quality lithic assemblage's post-1950 and over 200 open-air sites. In contrast, there are 13 cave sites pre-1950 and only 8 open-air sites. This may be due to the majority of cave sites being already discovered and excavated during the late 1800's and early 1900's due to their high visibility and possibly public interest value.



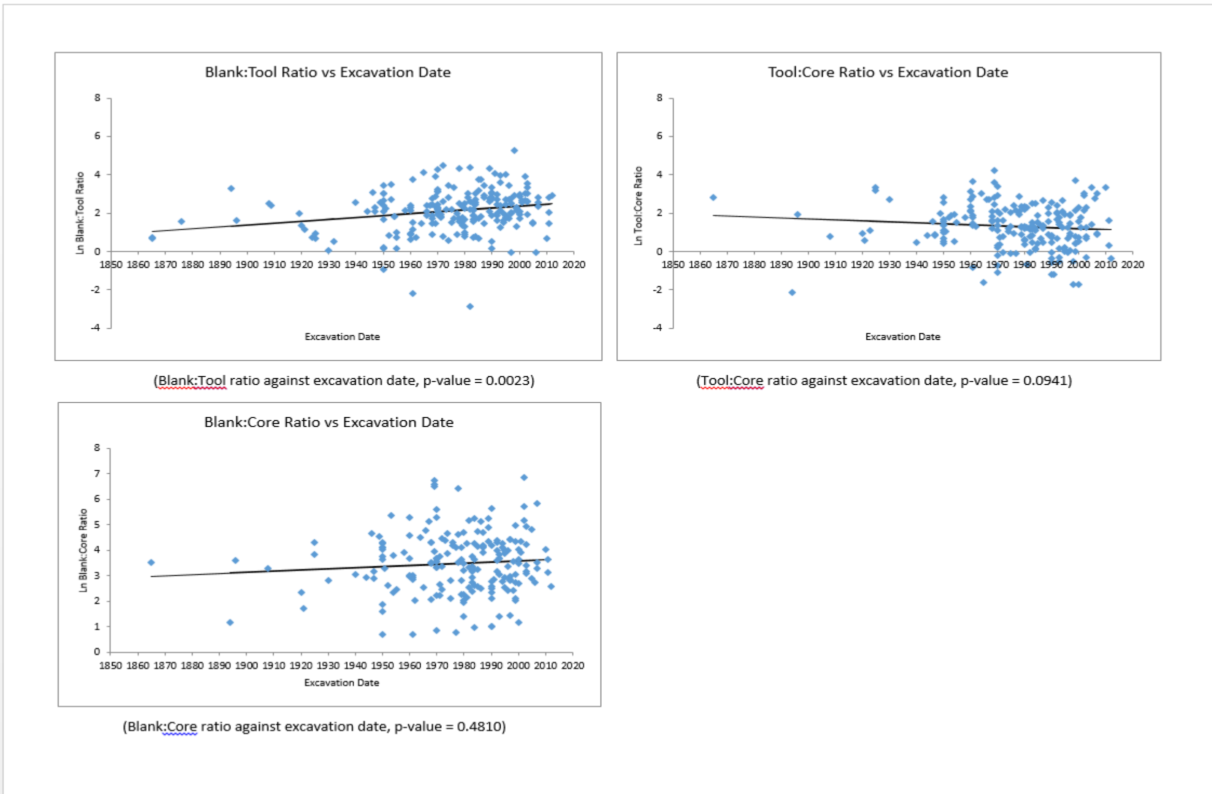
(Fig 3.12, Total lithic assemblage against excavation date and number of cave and open-air site lithic assemblages)



(Fig 3.13, Sum of blanks, tools, and cores against excavation date and number of cave and open-air site lithic assemblages)

3.2d - Relationship between excavation dates and artefact ratios

An important aspect of analysis and comparison in this study, is the ratio of components of the lithic artefacts, mainly blanks, tools, and cores. Several ratios have been proposed in Chapter 2 in the hope to gain an insight into how hunter-gatherer mobility and behaviour changed during dramatic climate shifts. Fig 3.14 shows three of the argued measures of hunter-gatherer mobility change: the blank/tool (B/T), blank/core (B/C), and tool/core (T/C) ratios. It is vital to understand how such measures may be affected by the excavation date. It could generally be argued that B/T and B/C ratios should increase as blanks become more readily reported in more recent excavations, while the T/C ratio should decrease as more cores tend to be reported in more recent excavations. This can be seen in Fig 3.14. However, both the T/C ($R = 0.083$; $p = 0.169$) and B/C ($R = 0.084$; $p = 0.481$) ratios appear to have no significant relationship with excavation date, while the B/T ratio ($R = 0.223$; $p = 0.004$) appears to have a potentially statistically significant relationship with excavation date, although with a very weak correlation. One way to mitigate this would be to exclude all the earlier excavation data. Fig 3.15 shows how this relationship changes when all sites pre-1940, 1950 and 1960 are excluded. This is not necessary with the T/C and B/C ratios as there is no significant relationship with excavation date, and thus should not have an effect on any analysis.



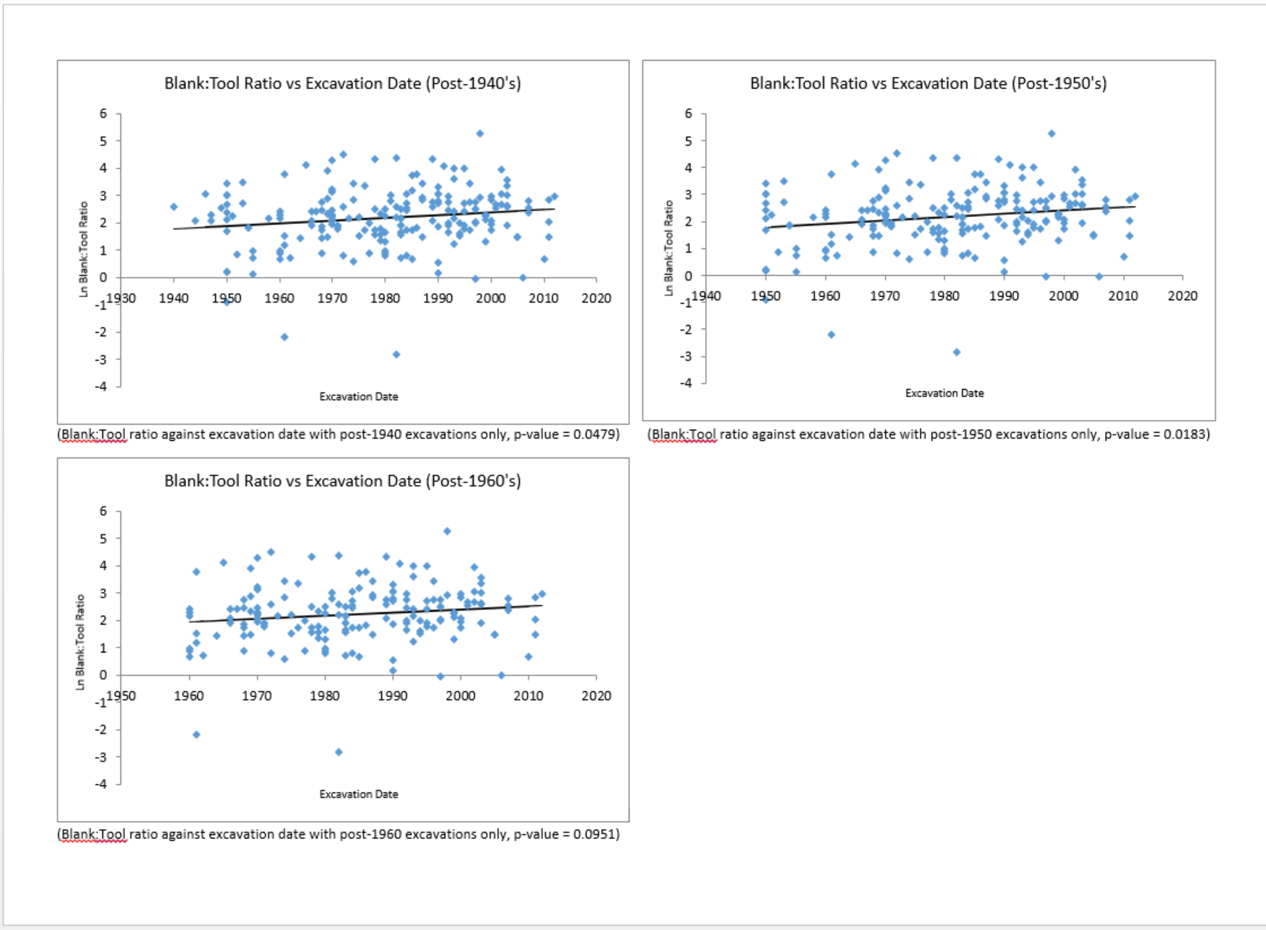
(Blank:Tool ratio against excavation date, p-value = 0.0023)

(Tool:Core ratio against excavation date, p-value = 0.0941)

(Blank:Core ratio against excavation date, p-value = 0.4810)

(Fig 3.14: The B/T, B/C, and T/C ratios vs excavation date)

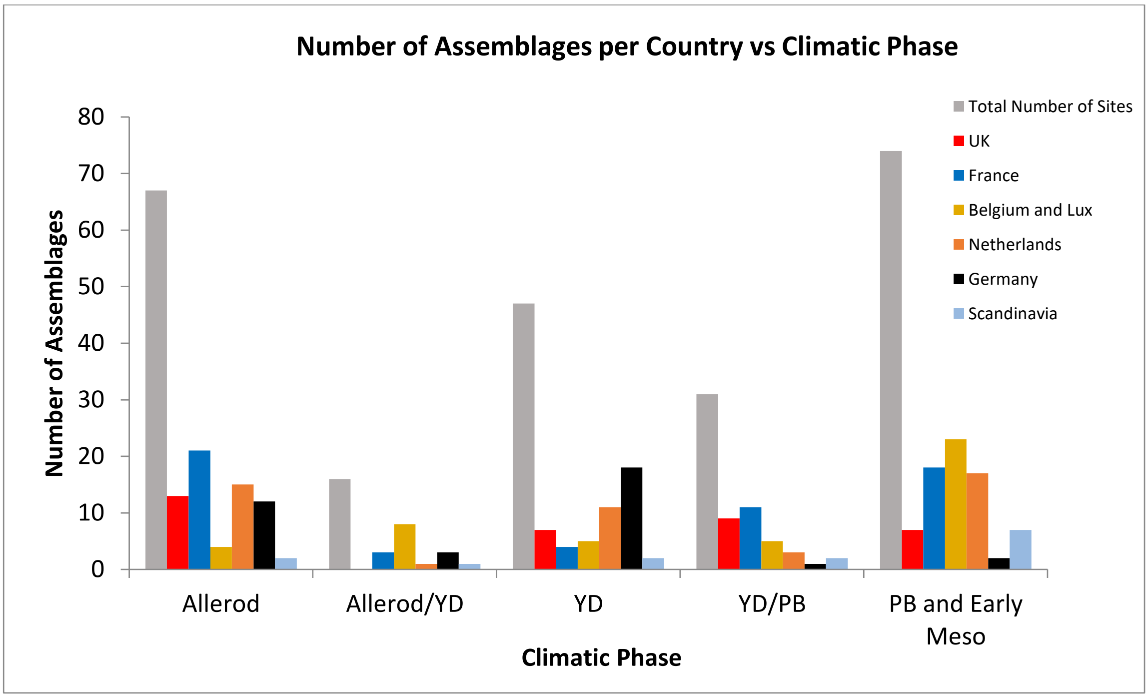
Fig 3.15, shows a notably more even distribution of assemblages when pre-1940's excavations are excluded with, no significant correlation between B/T ratio and excavation date (R = 0.147; p = 0.068). However, when testing assemblages excluding pre-1950's excavations there is a weak, positive, correlation with a significant statistical relationship (R = 0.167; p = 0.035). It is not until we exclude excavations pre-1960's, we see a non-significant relationship between the B/T ratio and excavation date in the following decades to the present. As excavation techniques and methods were of variable quality pre-1960 it was decided to exclude all pre-1960 excavated assemblages as a precautionary measure in order to definitively eliminate excavation date bias.



(Fig 3.15: B/T ratio vs excavation dates excluding decades from pre-1940, 1950, and 1960)

3.2e - Regional Variations

It is important to determine whether there are regional biases in the composition of the database. Fig 3.16 shows the number of sites per country of origin against each climatic phase (also see map for geographic distribution of sites in Appendix 1 pg. 307). When we look at the three main climatic phases, the Allerød, the YD, and the PB, we can see different regional biases in each. The Allerød has a high proportion of French sites, and the highest proportion of UK sites, but generally has quite an equal distribution, with the exception of Belgium. The YD has a very high proportion of German sites and quite a high proportion of Dutch sites with a very low number of French sites. The German sites appear to be over-represented in this sample. The PB has a very high proportion of Belgian sites and a high proportion of French and Dutch sites, and the highest proportion of Scandinavian sites. German sites appear to be significantly under-represented in this sample while the Belgian sites appear to be over-represented considering the size of the country and the numbers of sites from this country in the other climatic phases.



(Fig 3.16: Number of Assemblages per country against climatic phase)

3.2f – Summary of the Effects of Excavation Dates on my Data

The vast majority of sites in the dataset are from more recent excavations post-1940 with a large proportion from post-1980, meaning that, as far as excavation quality is concerned, this dataset can be considered very reliable. There is a significant bias in site type and excavation date, with almost exclusively cave sites with lithic assemblages excavated pre-1940 with 14 of the 22 cave sites with excavation dates recorded, and only 2 open-air sites. This picture is in stark contrast to sites excavated post-1940, where only 8 cave sites with lithic assemblages were excavated compared with 212 open-air sites. The comparative lack of caves with good quality lithic assemblage's post-1940 may be a result of the comprehensive recording and excavation of these sites prior to 1940 and the possibility many lithic assemblages dating to this period in cave sites were unwittingly destroyed or overlooked by excavators in the pursuit of older and/or more attractive artefacts. This poses an interesting question as to if cave sites pre-1940 should be considered unreliable and excluded. However, there is an argument that the cave sites post-1940 show no significant difference in numbers of artefacts to their post-1940 counterparts, which may suggest that older cave excavations may in fact recovered the majority of artefacts.

The B/T ratio has a statistically significant relationship with excavation date which is an issue, as this may interfere with the results and interpretations when comparing these two variables. It has been suggested older excavations may have to be excluded from this plot when analysing blank-tool relationships. It has been proved sites excavated post-1960 show no significant relationship between B/T ratio and excavation date, and can be considered more reliable for analysis. The B/C and T/C ratios show no statistically significant relationship with excavation date within the whole dataset so can be considered reliable. However, as the B/T ratio is compromised by excavation date there may be an unseen bias in the B/C and T/C ratios which also requires caution when interpreting results.

Area of excavation affects numbers of artefacts as would be expected. However, excavation area decreases with time. As excavation area data was only available for sites post-1950, only these assemblages could be compared. It was found there is a statistically significant, negative relationship. This most likely a result of increasing numbers of rescue excavations in more modern times, which are smaller in nature, or possibly a result of smaller sites being considered more important recently, compared with earlier excavations.

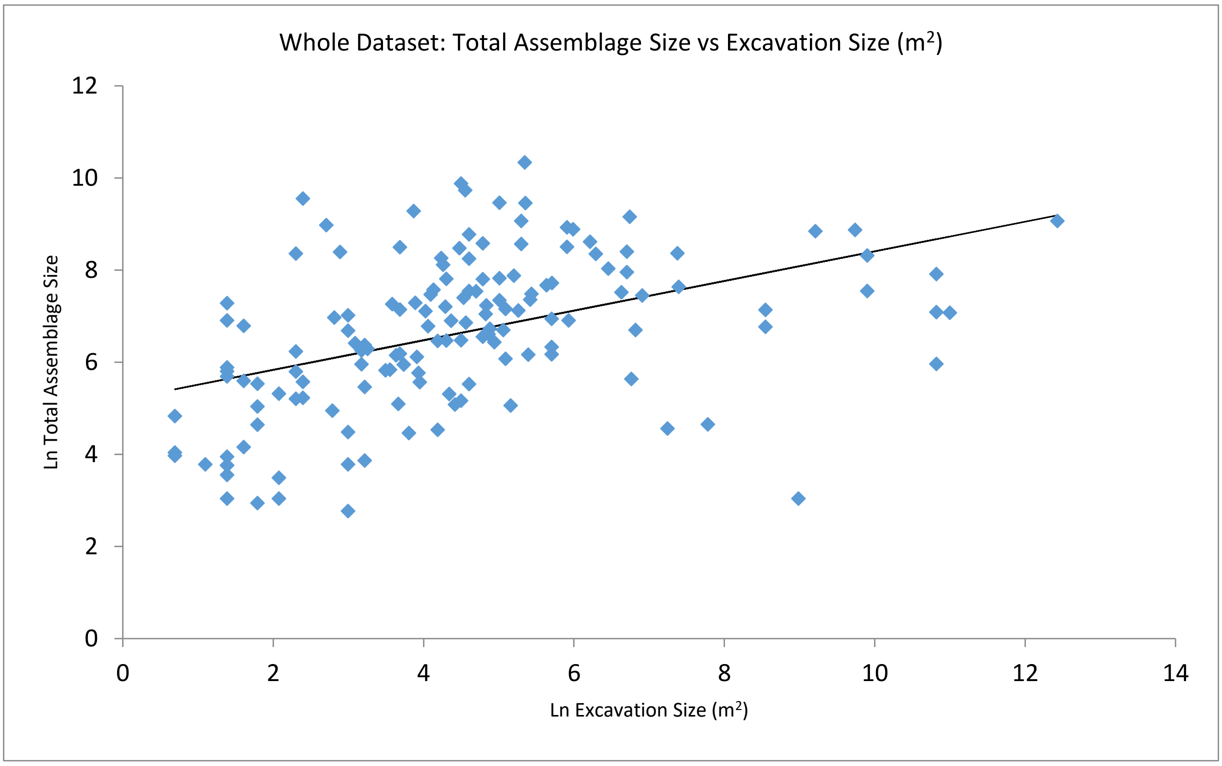
There are no statistically significant relationships between the total number of artefacts and excavation date. There is an initial significant relationship with the total lithic artefacts with excavation date. However, this was found to be due to the more common reporting of lithic waste products such as shatter and debitage in more recent excavations. When excluding earlier excavated sites pre-1940, and when such waste material was excluded from the total artefact count, this relationship disappeared, proving there is no relationship between the total number of artefacts and excavation date, and that these numbers can be confidently compared.

3.3 - Excavation Size and Altitude

3.3a - Excavation Size

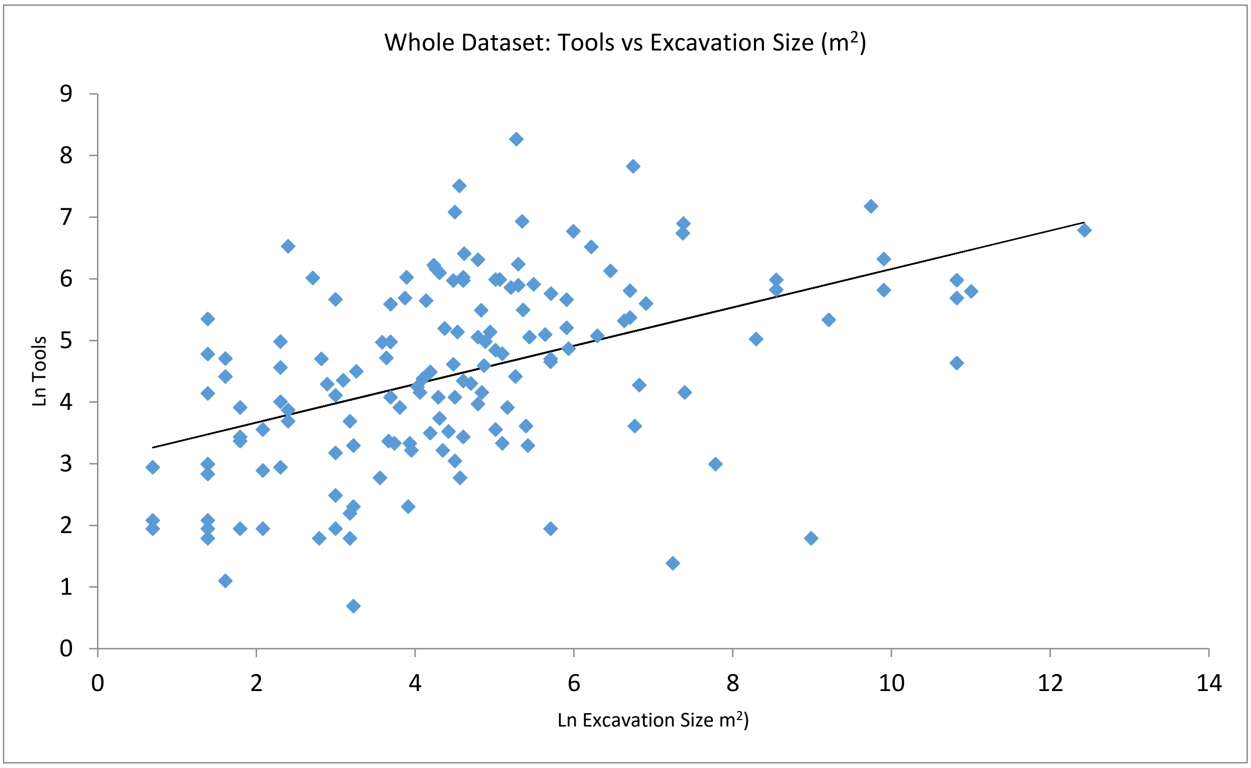
The numbers of artefacts may also be driven by the size of an excavation (larger area excavated would be expected to have larger numbers of artefacts) and the preference of where in the landscape is excavated (for example biases towards lowland sites for rescue archaeology carried out on road and other building projects at the expense of upland excavations). Consequently, excavation size and altitude was plotted against the percentage of total tools, hunting tools, and domestic tools in the total assemblage and in the tool assemblage (in the case of hunting and domestic tools).

It would be expected, as excavation size increases so would the number of tools and domestic tools. However, one might expect that the number of hunting tools would decrease if the assumption is made that larger sites tend to be "domestic" camps, especially within a logistical strategy. It can be seen from Fig 3.17 there is indeed a trend towards larger excavations containing larger numbers of artefacts. However, this trend has a weak correlation (R = 0.448) and there is no strong evidence to suggest a significant relationship between excavation size and the total assemblage driving the results.

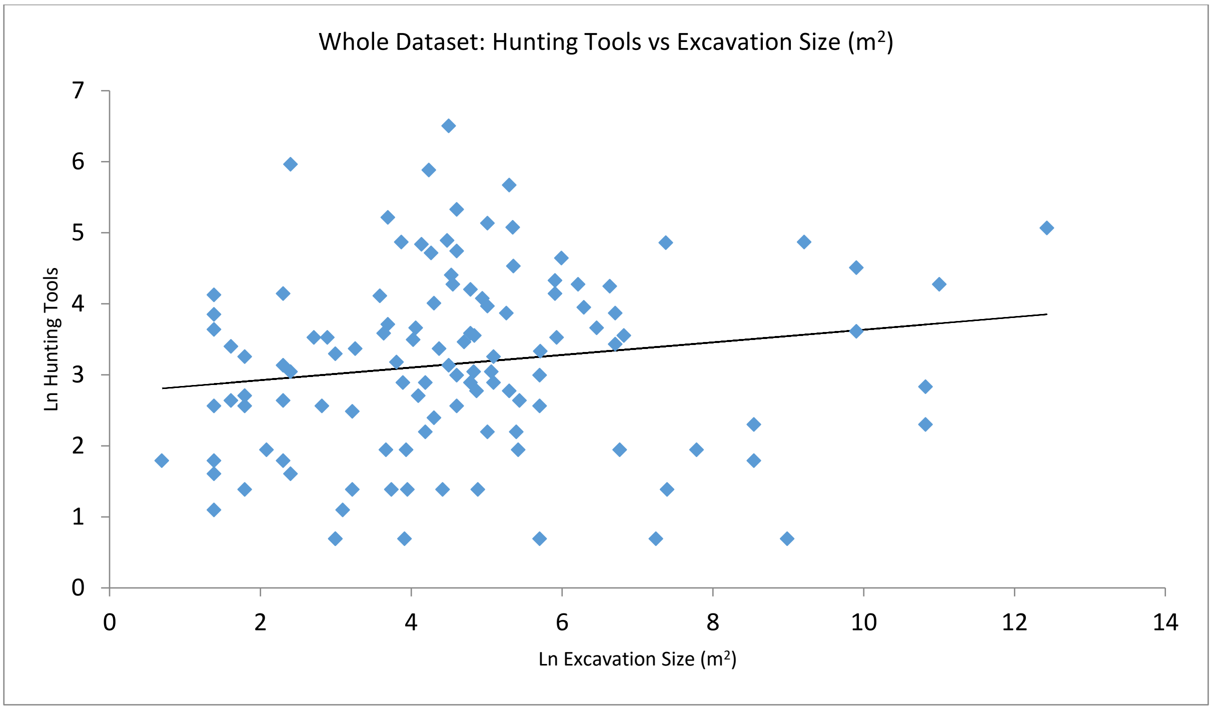


(Fig 3.17: Total assemblage size against excavation size for the whole dataset. R = 0.448, p = 4.660E-42)

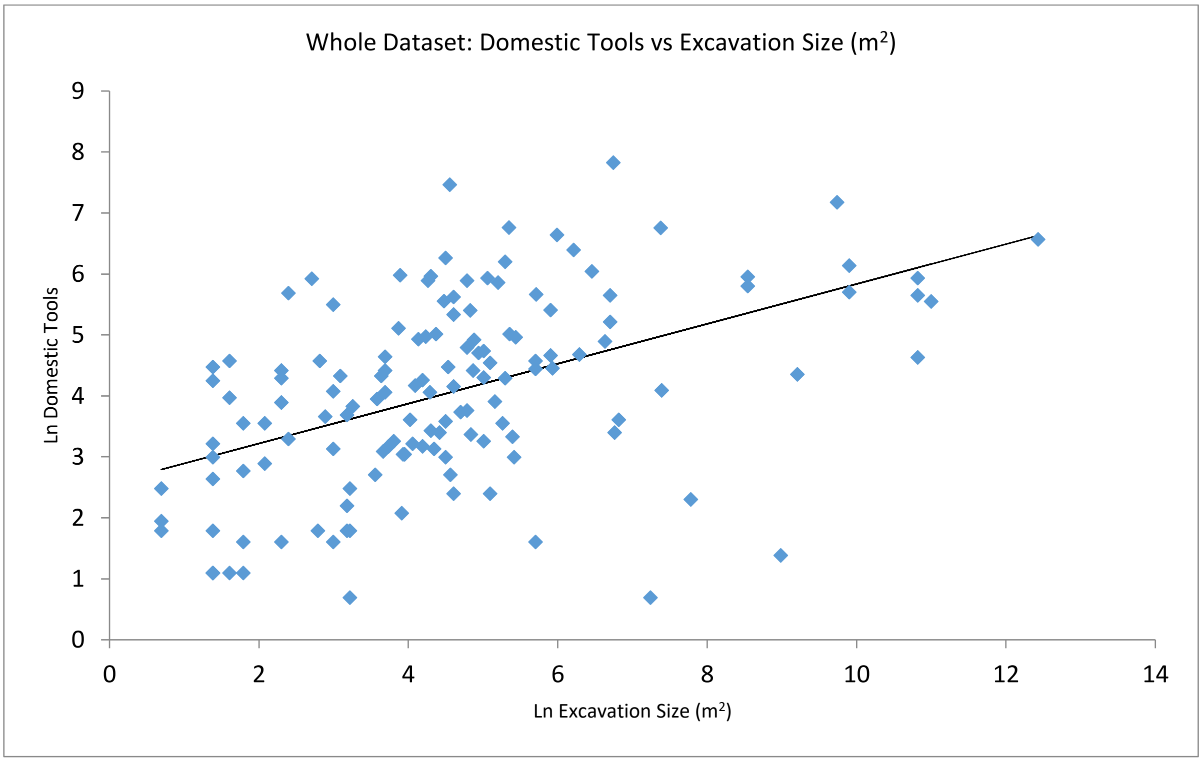
There is a similar trend with a similarly weak correlation when, looking at the number of tools, hunting tools, and domestic tools (see definitions for what constitutes hunting and domestic tools in the glossary of tool definitions in Appendix 1) against excavation size (Figs 3.18, 3.19, 3.20), and there is a distinctly weaker correlation when looking at the numbers of hunting tools. Broadly speaking, one would expect there to be increasing numbers of total tools and the domestic tool component, and possibly decreasing numbers of hunting tools, which to some extent seems true when looking at these distributions. However, no significantly strong evidence exists suggesting excavation size is driving the numbers of artefacts in this dataset.



(Fig 3.18; Tool assemblage size against excavation size for the whole dataset. R = 0.470; p = 1.133E-24)



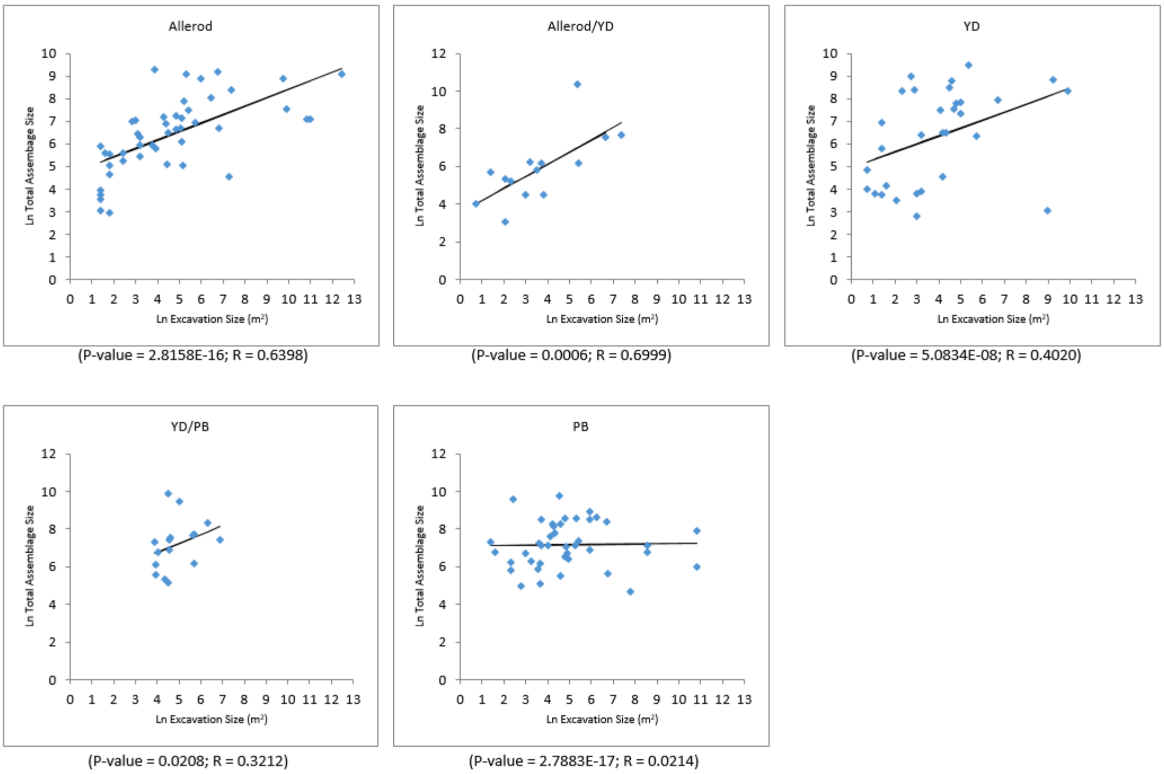
(Fig 3.19; Hunting tool assemblage size against excavation size for the whole dataset. R = 0.156; p = 1.159E-17)



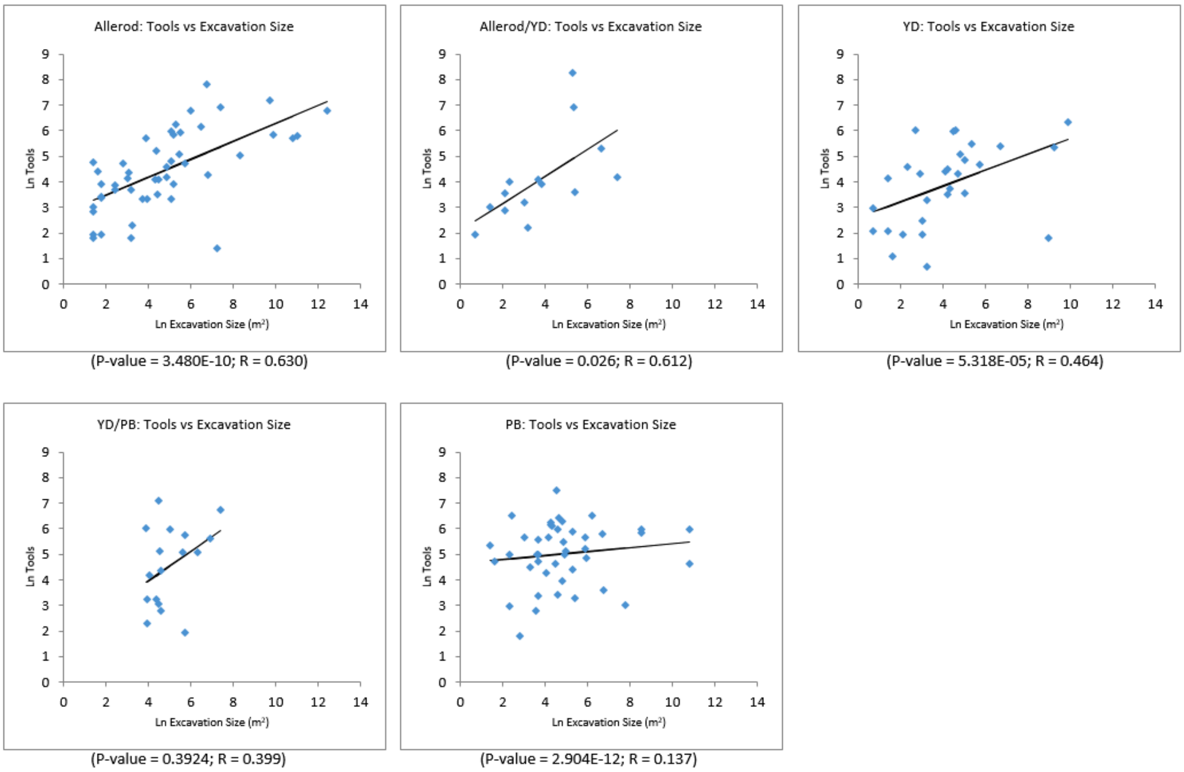
(Fig 3.20; Domestic tool assemblage size against excavation size for the whole dataset. R = 0.489; p = 2.670E-18)

These results show no significantly strong evidence suggesting that the numbers of tools and their hunting and domestic components are driven by excavation size. With regard to this study, this suggests any problems arising from larger sample sizes from larger excavations are minimal. However, there is still a weak trend of increasing numbers of tools with increasing excavation size, which one would expect, and it would be sensible to keep this in mind, especially when acknowledging the issues of sample size and larger excavations experienced in many other archaeological studies.

When looking at the total assemblage size against excavation size for each climatic phase (Fig 3.21), it can be seen the Allerød and Allerød/YD transition have a notably stronger significant correlation ($R = 0.6398$ and $R= 0.6999$ respectively) than the YD, YD/PB, and PB, with increasing numbers of artefacts with excavation size. Although stronger than the whole dataset values, it still provides no significantly strong evidence to suggest this is driven by excavation size alone. The YD displays a similar trend, but with a weaker correlation along with the YD/PB transition, which has a notably small sample size. Interestingly, the PB has a distinct distribution showing no real change in the numbers of artefacts with excavation size. However, there is a very weak correlation ($R = 0.0214$), suggesting there is no significantly strong relationship here. Overall, there again appears to be no significant evidence that excavation size drives assemblage size in any of the individual climatic phases, but with a case for a slightly stronger correlation occurring in the Allerød and Allerød/YD transitional phases. These trends are similarly echoed in the number of tools against excavation size (Fig. 3.22).

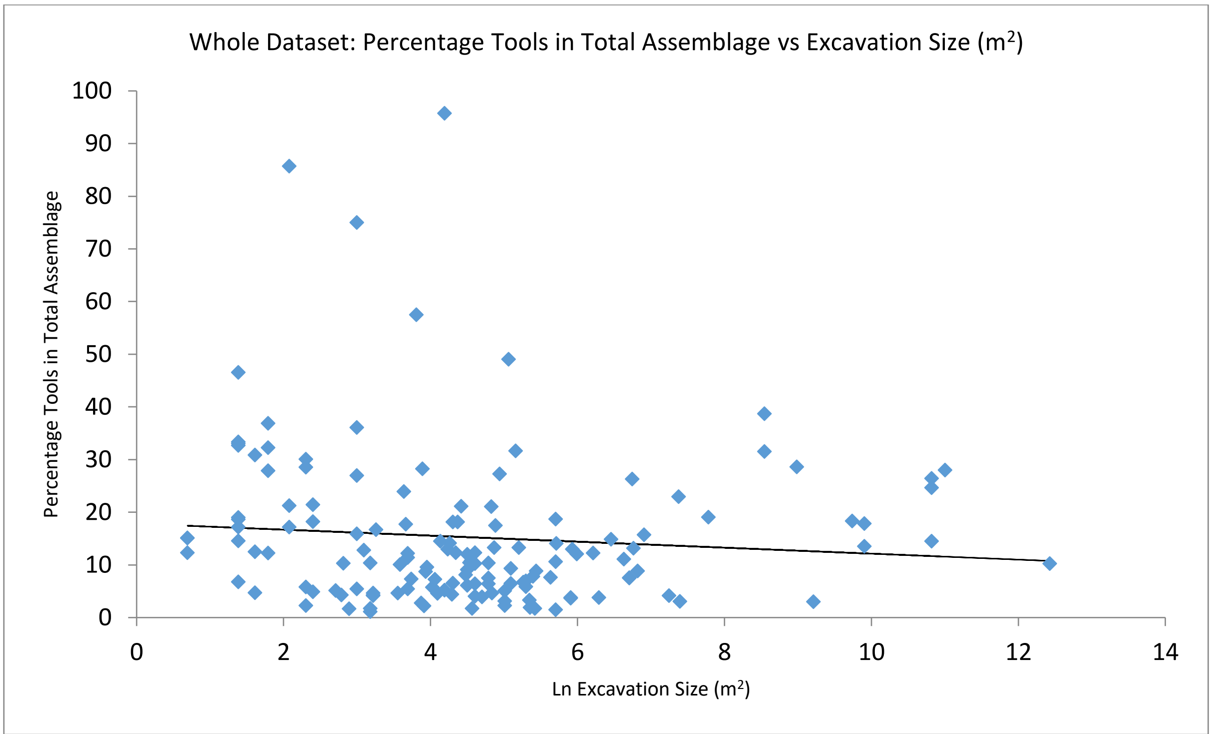


(Fig 3.21: Total assemblage size against excavation size for each climatic phase)



(Fig 3.22: Number of tools against excavation size in each of the climatic phases)

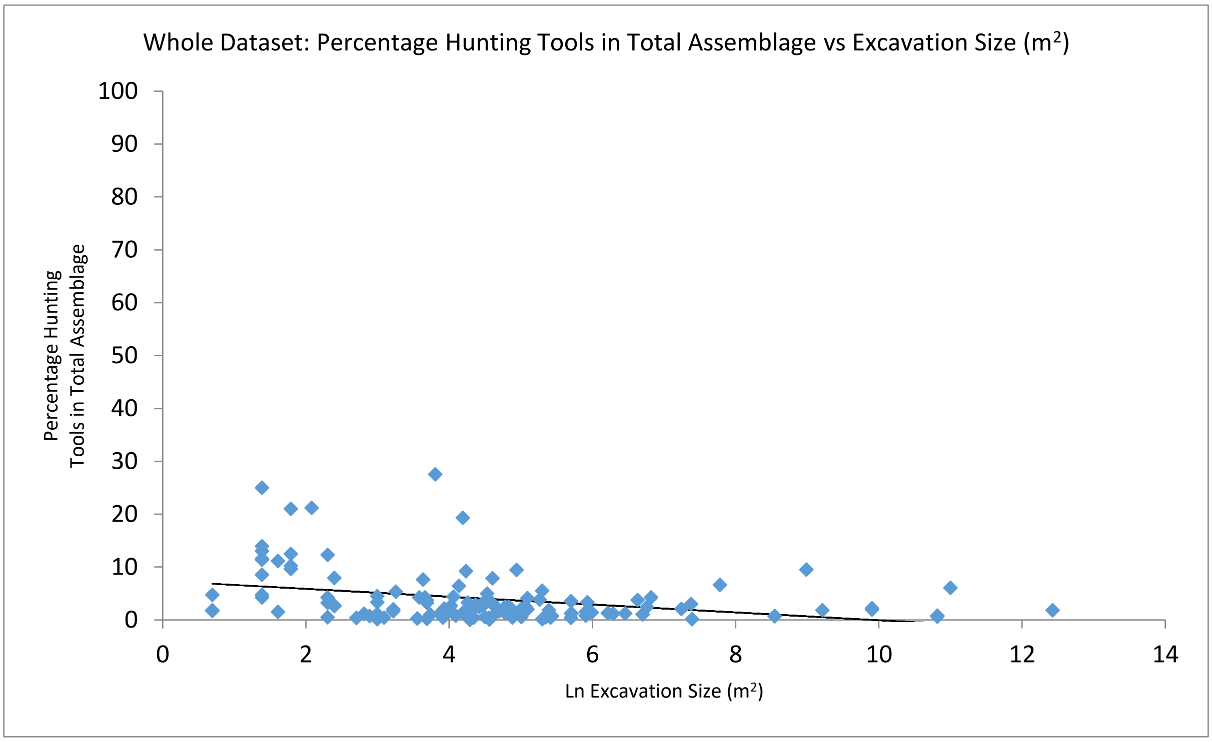
The above analyses focused on the total numbers of artefacts, but is there a relationship between the percentage of tools and their hunting and domestic components and excavation size? One might expect that in larger excavations the percentage of tools might decrease as the number of blanks and cores increase in comparison to smaller assemblages. Fig 3.23 shows the percentage of tools in the total assemblage against excavation size. It is clear there is no obvious relationship, with a possible slight decline in the percentage of tools in larger excavations. The correlation is very weak (R = 0.089) and thus no evidence appears for excavation size driving the percentage tools in the total assemblage.



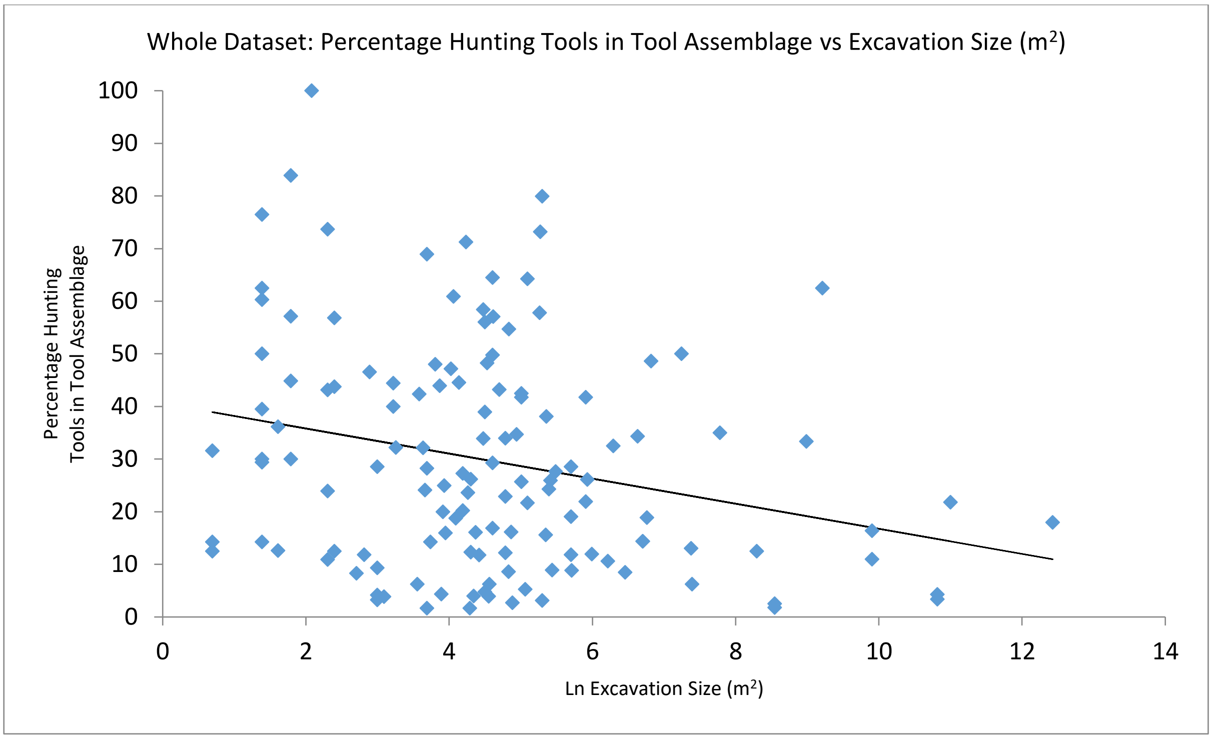
(Fig 3.23: Percentage tools in the total assemblage against excavation size. R = 0.089; p = 7.765E-10)

The evidence from hunting tools (Figs 3.24, 3.25) shows there is a possible, weak trend of decreasing numbers of hunting tools with increasing excavation size. Lower percentages of hunting tools might be expected at larger sites which are often accepted as "domestic" sites in which one would expect less hunting activity. However, the correlation between the two variables are weak (R = 0.336 and 0.251 respectively) and there is no significantly strong evidence excavation size drives the percentage of hunting tools within an assemblage.

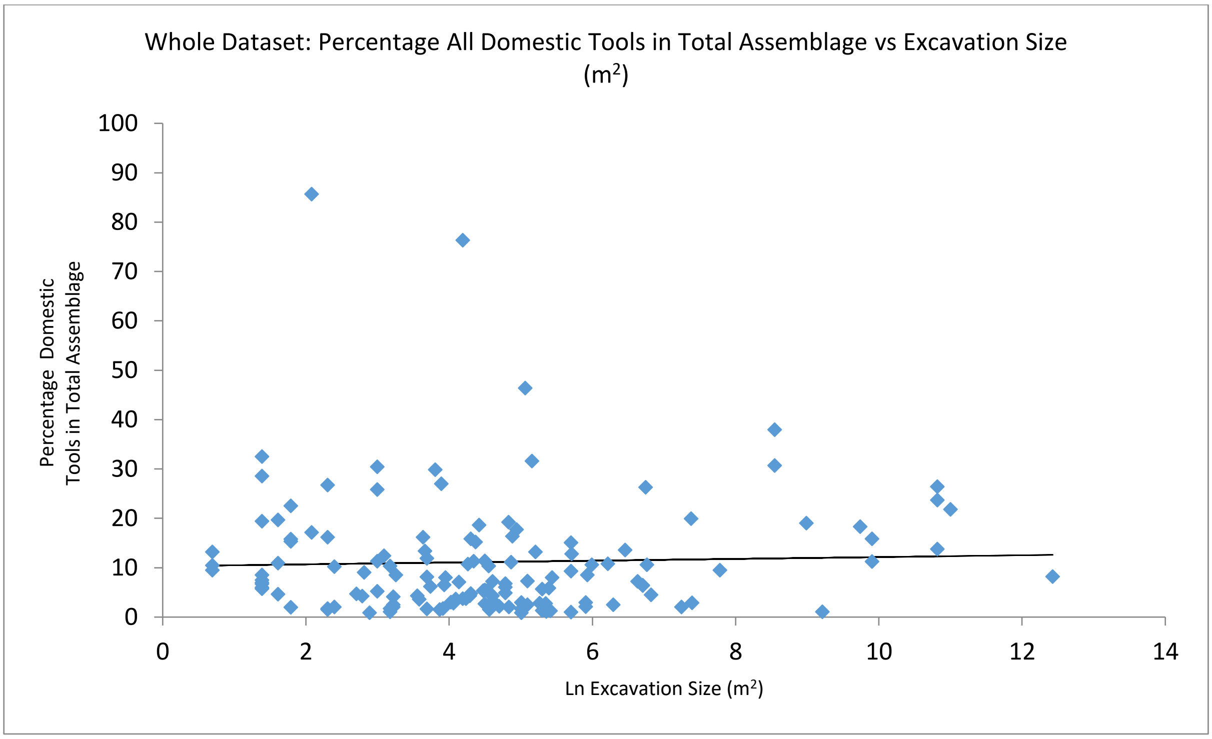
The evidence from the percentage of domestic tools in the total assemblage (Figs 3.26) shows a possible weak trend of increasing numbers of domestic tools with increasing excavation size, which one might expect as larger sites are associated with domestic camps, and thus would be expected to contain higher percentages of domestic tools. This appears to be more pronounced when looking at the percentage of domestic tools in the tool assemblage (Fig 3.27). However, again, there is a very weak correlation between the two variables in both sets of analyses (R = 0.035 and 0.204 respectively) suggesting there is no strong evidence there is a significant relationship between the percentage of domestic tools within an assemblage and excavation size.



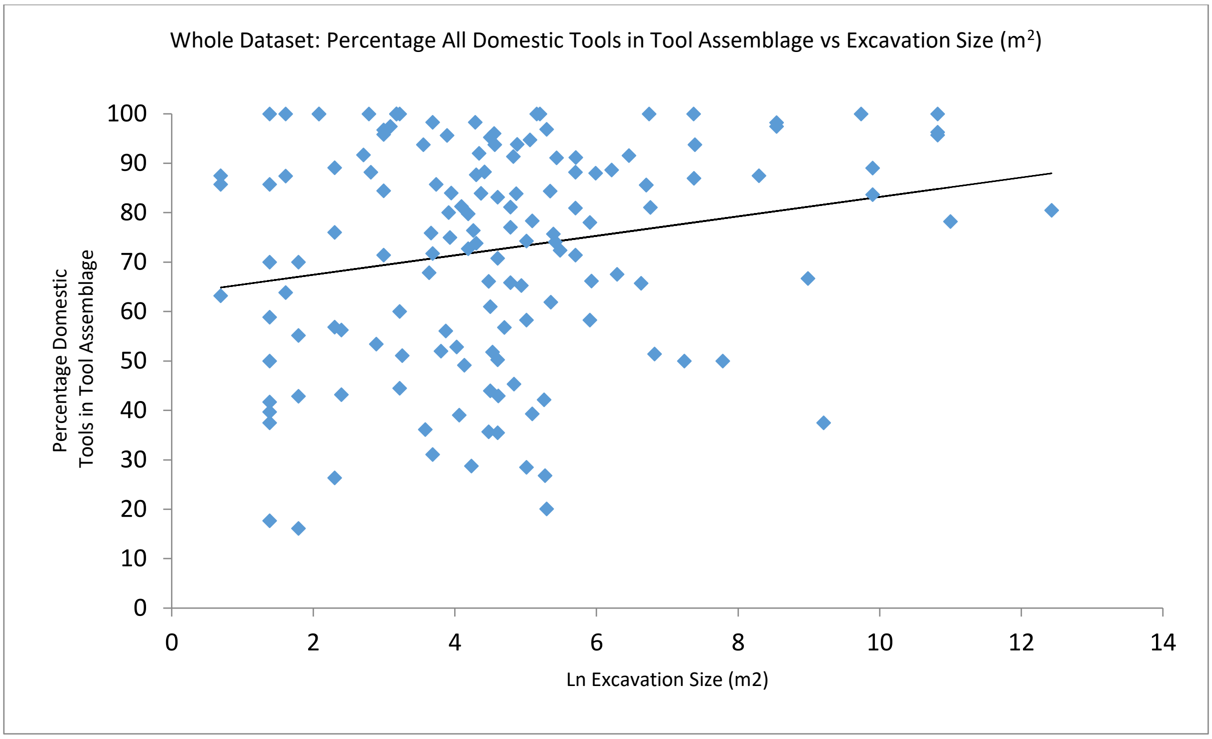
(Fig 3.24: Percentage hunting tools in the total assemblage against excavation size. R = 0.336; p = 1.761E-12)



(Fig 3.25: Percentage hunting tools in the tool assemblage against excavation size. $R = 0.251$; $p = 1.412E-17$)



(Fig 3.26: Percentage domestic tools in the total assemblage against excavation size. $R = 0.035$; $p = 1.298E-05$)

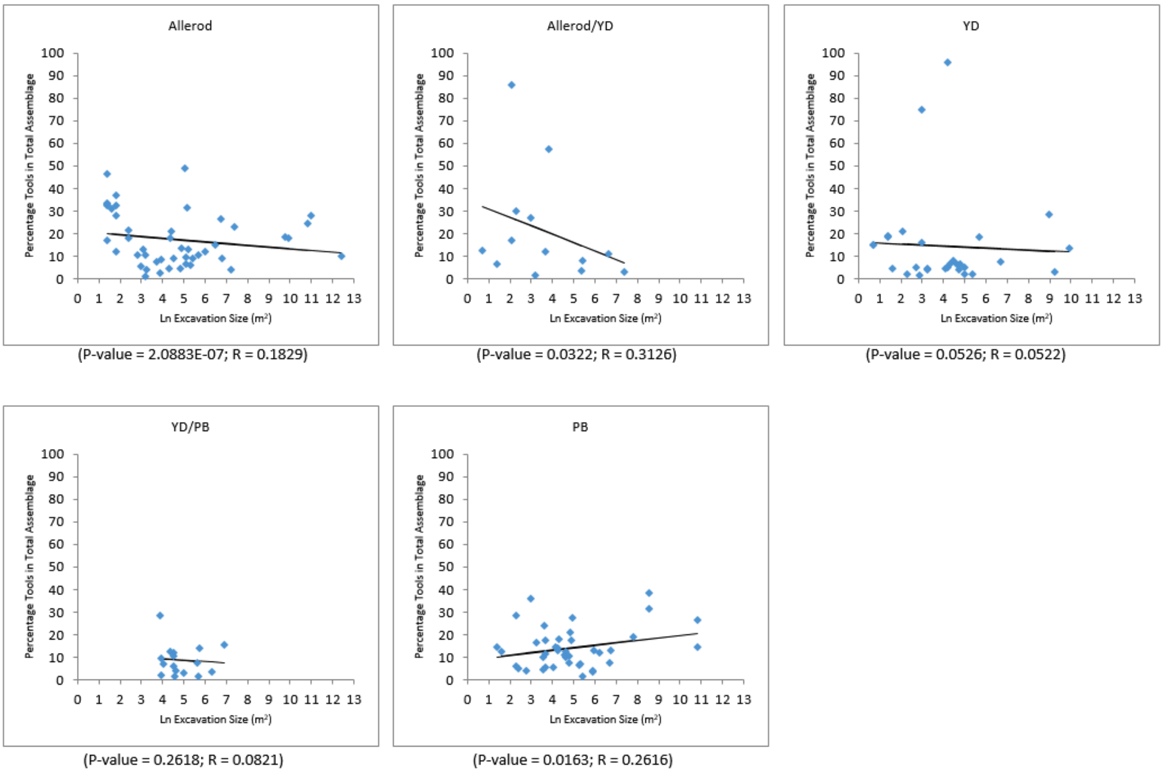


(Fig 3.27: Percentage domestic tools in the tool assemblage against excavation size. R = 0.204; p = 7.229E-33)

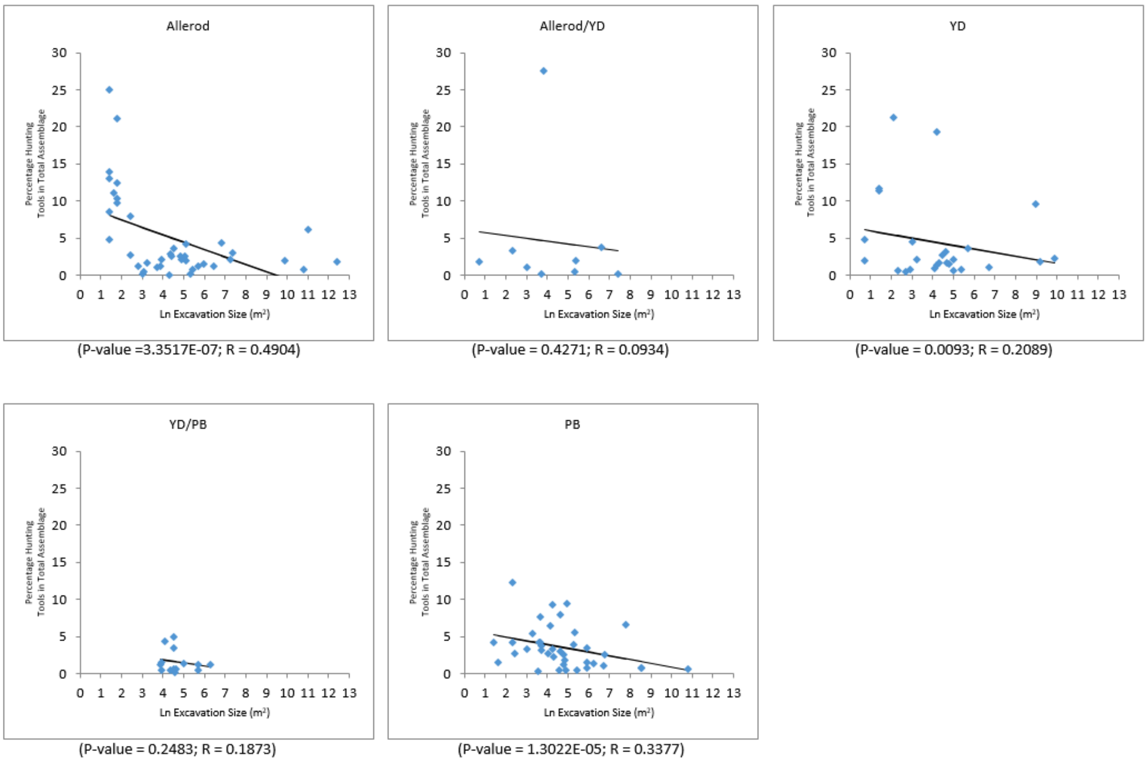
Does this change when looking at the individual climatic phases? The individual phases show slight differences in their distributions to that of the whole dataset. The percentage of tools (Fig 3.28) appear to have a slight negative, although weak, correlation in the Allerød, Allerød/YD (to a greater extent), YD, and YD/PB, while the PB has a weak positive correlation. This potentially indicates that there is a difference in the PB sample with a slight increase in the percentage of tools in the total assemblage, with increasing excavation size, rather than the decreases seen in the other periods. Overall, it appears there is no significant evidence any of the climatic phases are strongly influenced by excavation size. Interestingly, there might be a change that one could argue represents a shift in hunter-gatherer behaviour in the PB sample.

The percentage of hunting tools in the total assemblage (Fig 3.29) all appear to have a slight negative correlation in each climatic phase, with the Allerød displaying the most pronounced decrease in percentage tools to excavation size. Again, these correlations are very weak and provide no significant evidence that excavation size drives the percentage of hunting tools in the total assemblage. This pattern remains largely similar in the percentage of hunting tools in the tool assemblage (Fig 3.30) for the Allerød, YD, and PB. However, the transitional phases appear to show the opposite behaviour with notably positive correlations, possibly indicting a change in hunter-gatherer behaviour. Again, these correlations are very weak and provide no evidence of a strong relationship between these two variables.

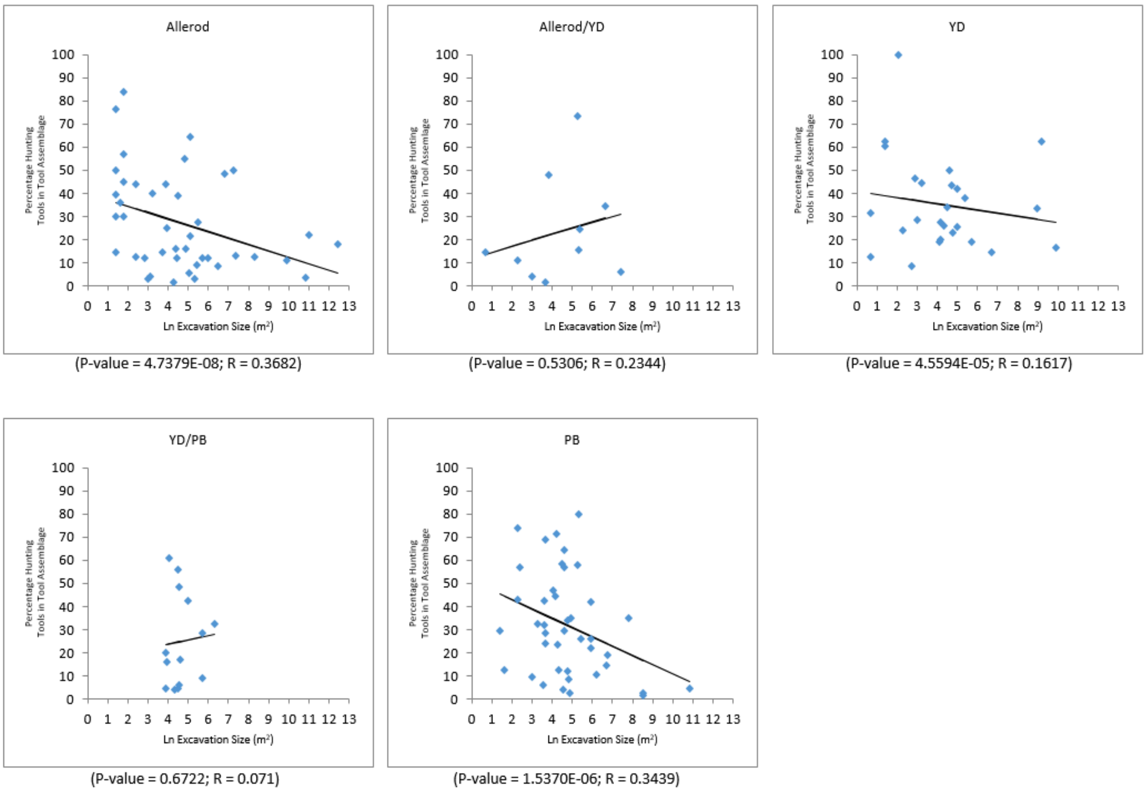
The percentage of domestic tools in the total assemblage (Fig 3.31) display no real changes in the percentage of domestic tools and the size of the excavation in the Allerød and YD samples. However, there is a notable positive correlation in the PB with increasing percentages of domestic tools with excavation size, and negative correlations in the transitional phases. These correlations are again very weak and do not provide any evidence that there is a strong relationship between these variables. It is interesting to note the positive correlation in the PB, which may tentatively hint at a possible change in hunter-gatherer behaviour, along with the transitional phases (however, the transitional phases have a notably low sample size). These patterns show a number of changes when compared with the percentage of domestic tools in the tool assemblage against the excavation size (Fig 3.32). The Allerød appears to have a distinct positive correlation which is even more pronounced in the PB. However, the YD shows no real change in the percentage of domestic tools with excavation size at all. The Allerød/YD transition has a distinctly negative correlation while the YD/PB transition has a slight positive correlation. Once again, all these correlations are very weak and provide no strong evidence that excavation size strongly influences the percentage of domestic tools in assemblages.



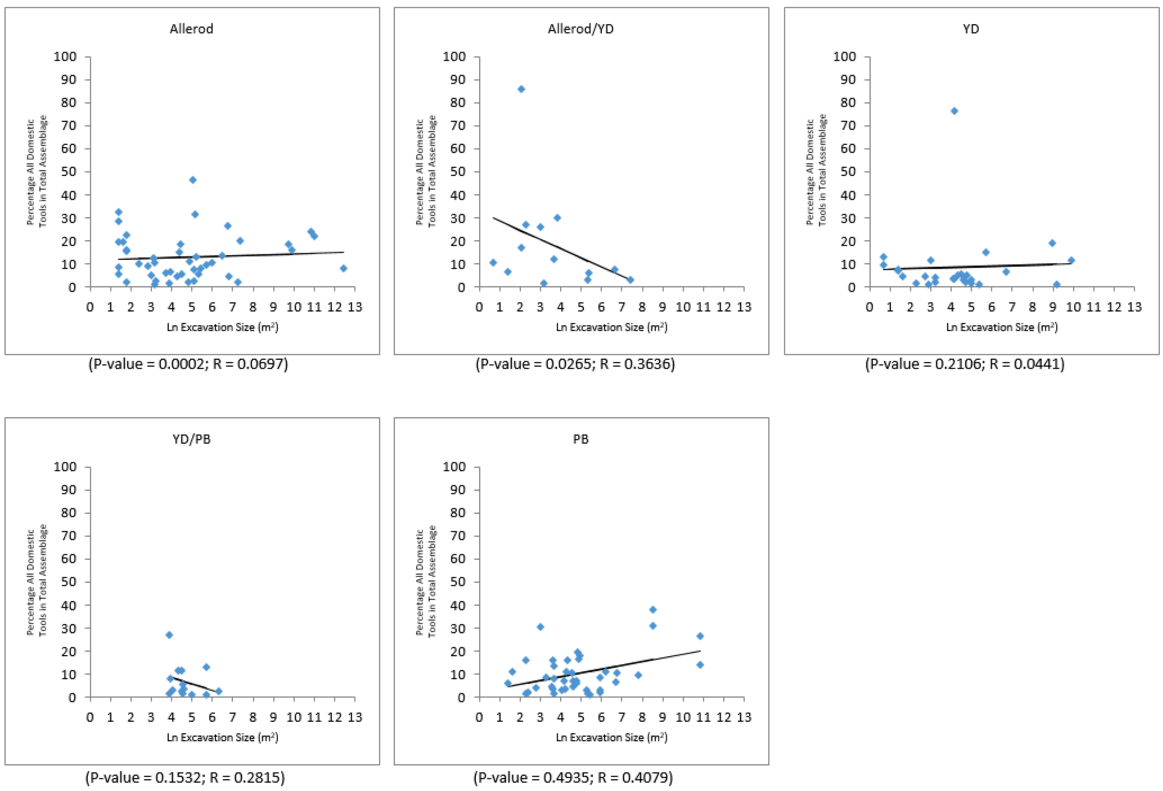
(Fig 3.28: Percentage tools in the total assemblage against excavation size for each climatic period)



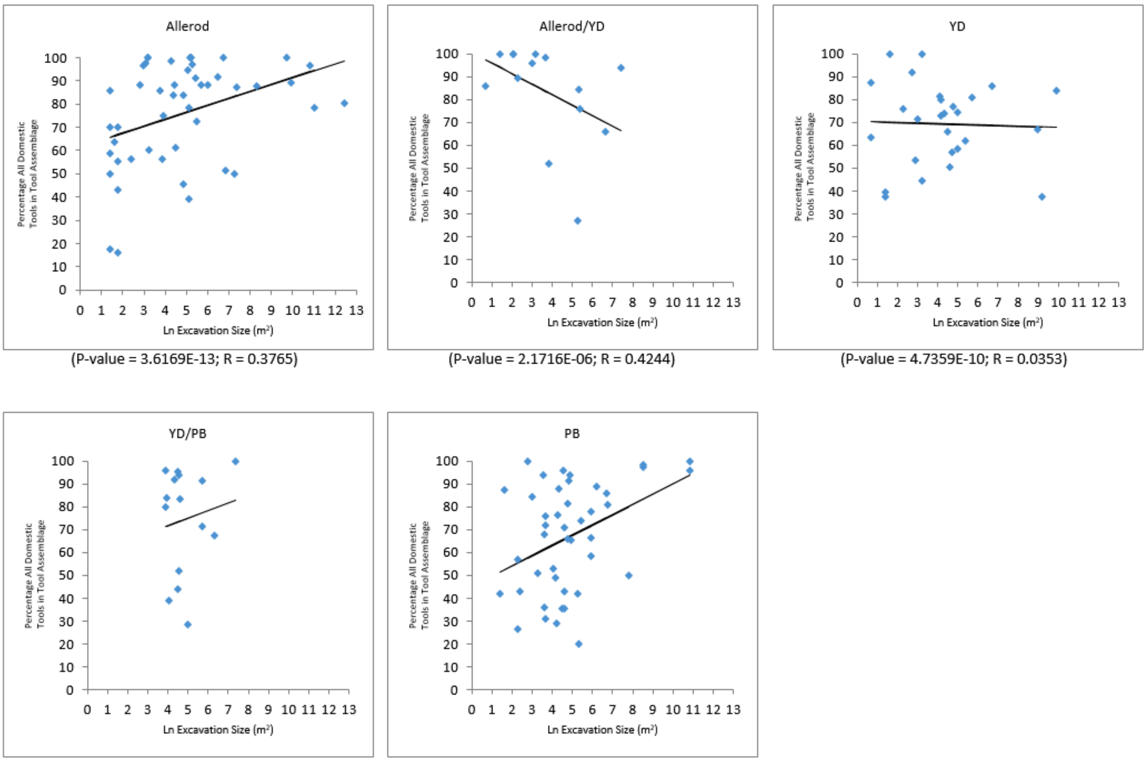
(Fig 3.29: Percentage hunting tools in the total assemblage against excavation size for each climatic period)



(Fig 3.30: Percentage hunting tools in the tool assemblage against excavation size for each climatic period)



(Fig 3.31: Percentage domestic tools in the total assemblage against excavation size for each climatic period)



(P-value = 3.6169E-13; R = 0.3765)

(P-value = 2.1716E-06; R = 0.4244)

(P-value = 4.7359E-10; R = 0.0353)

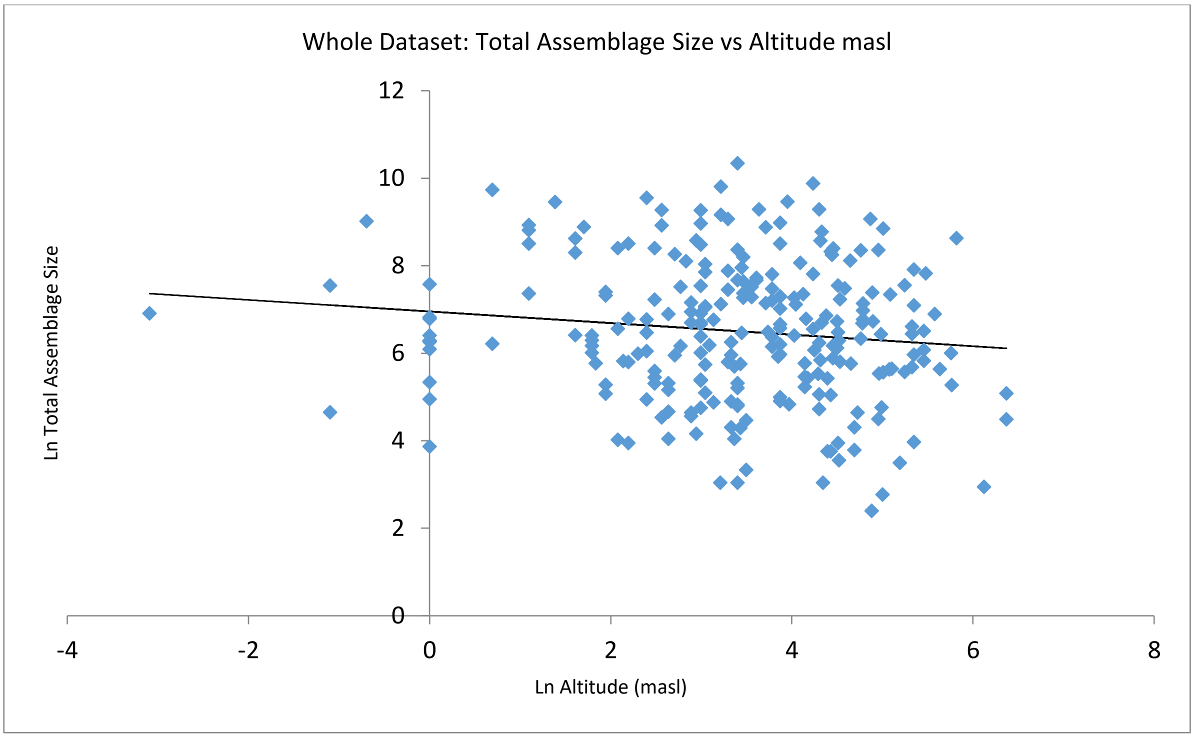
(P-value = 0.0899; R = 0.1442)

(P-value = 5.1383E-06; R = 0.3939)

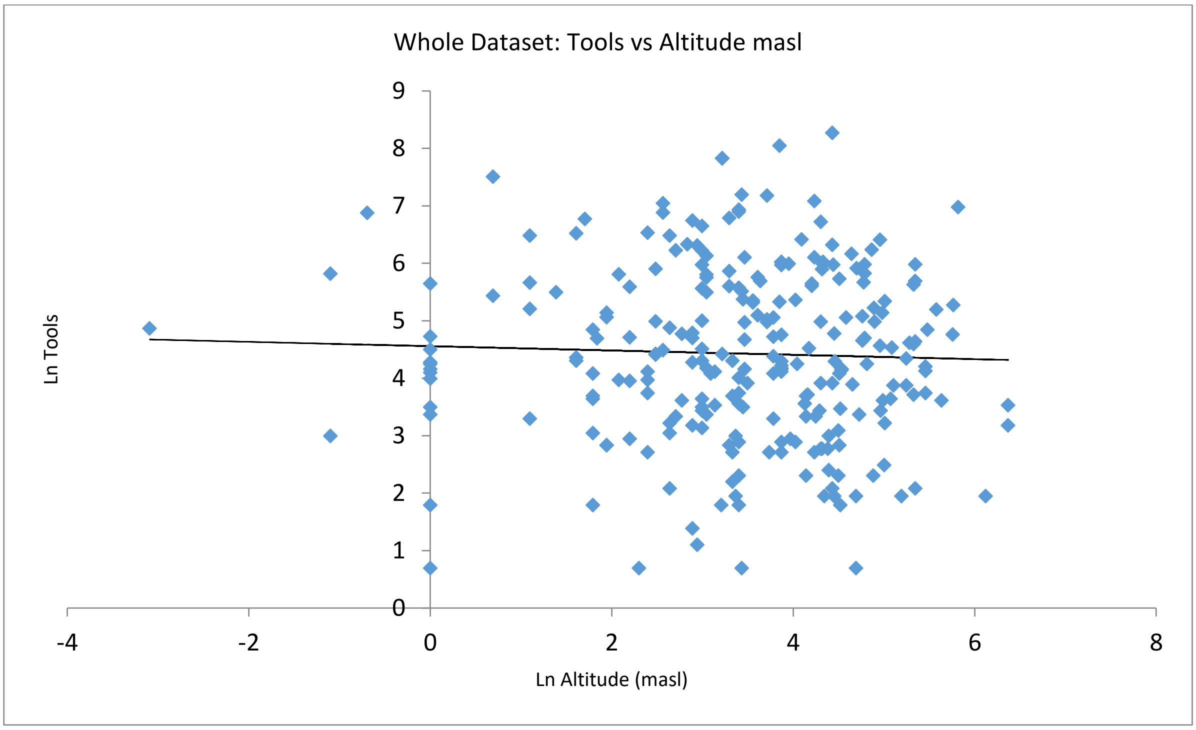
(Fig 3.32: Percentage domestic tools in the tool assemblage against excavation size for each climatic period)

3.3b - Altitude

It would be expected, that as altitude increases, the number of tools and domestic tools would decrease if the assumption is made that sites at higher altitude tend to be logistical/special task orientated camps, and thus would have a lower proportion of domestic tools. Conversely, the opposite might be expected with hunting tools, with increasing numbers as altitude increases, representing a higher proportion of hunting camps (at least within a more logistical strategy). It can be seen from Fig 3.33 there is a slight general trend of decreasing total assemblage size as altitude increases, loosely following the expectations. However, this trend has a very weak correlation (R = 0.124) and provides no strong evidence altitude is driving the total number of artefacts in an assemblage.

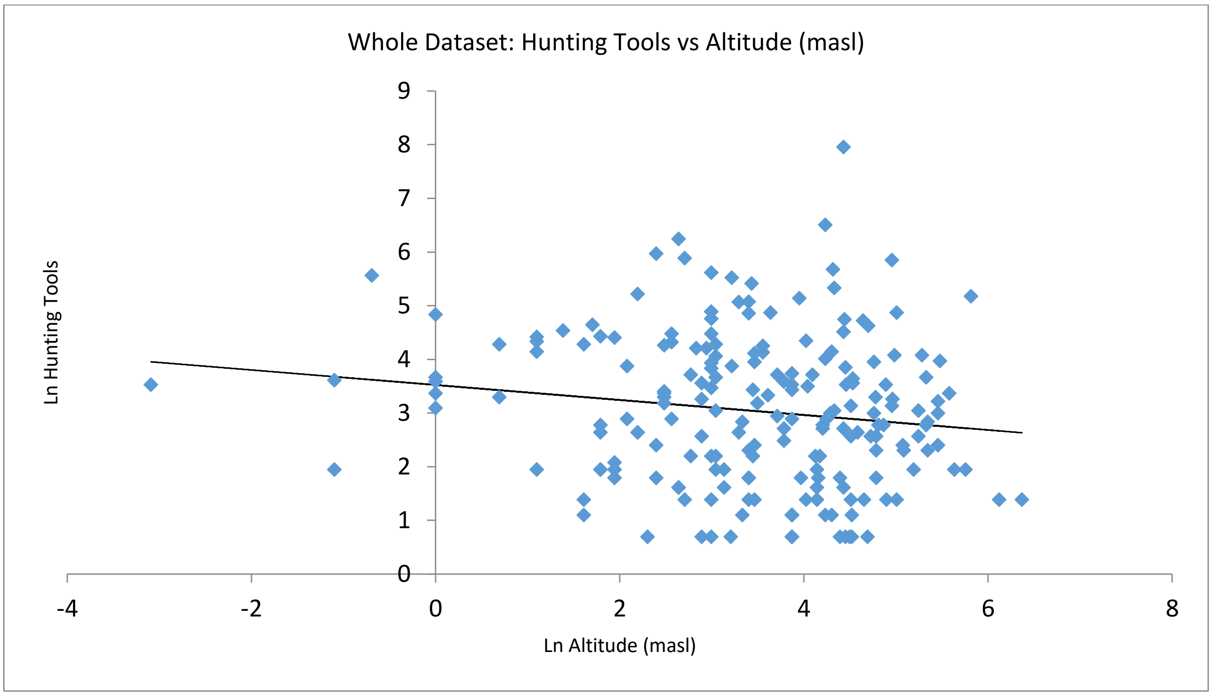


(Fig 3.33: Total assemblage size against altitude for the whole dataset. R = 0.124; p = 4.569E-77)

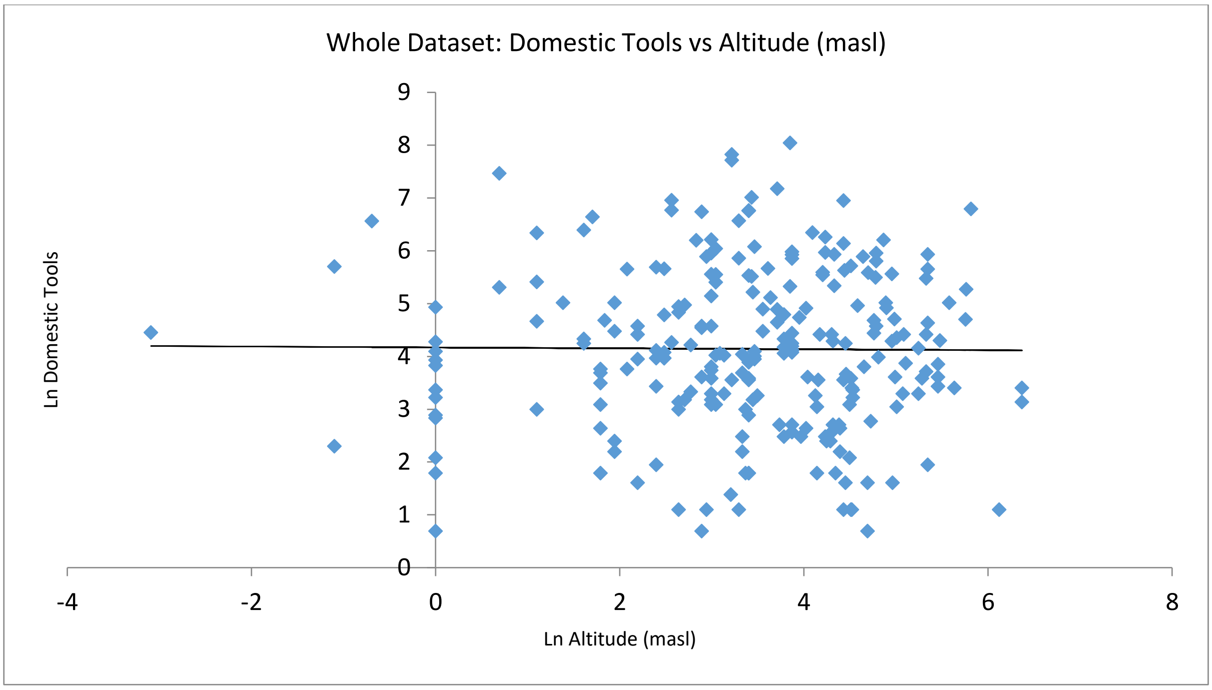


(Fig 3.34: Tool assemblage size against altitude for the whole dataset. R = 0.037; p = 1.169E-51)

A similar trend is observed in the number of tools and in the domestic tool component (Figs 3.34, 3.36). These trends have even weaker correlations than the total assemblage size (R = 0.037 and 0.310 respectively) and no evidence for a strong relationship between the number of tools and the domestic tool component and altitude. This further reinforces the evidence from the total assemblage size. Of possible interest is that hunting tools against altitude (Fig 3.35) displays a more distinct negative trend. This is unexpected, as hunting sites are often associated with upland territories, which afford good views across the landscape. However, again, this trend is weakly correlated (R = 0.119) and provides no strong evidence the number of hunting tools is significantly driven by altitude.



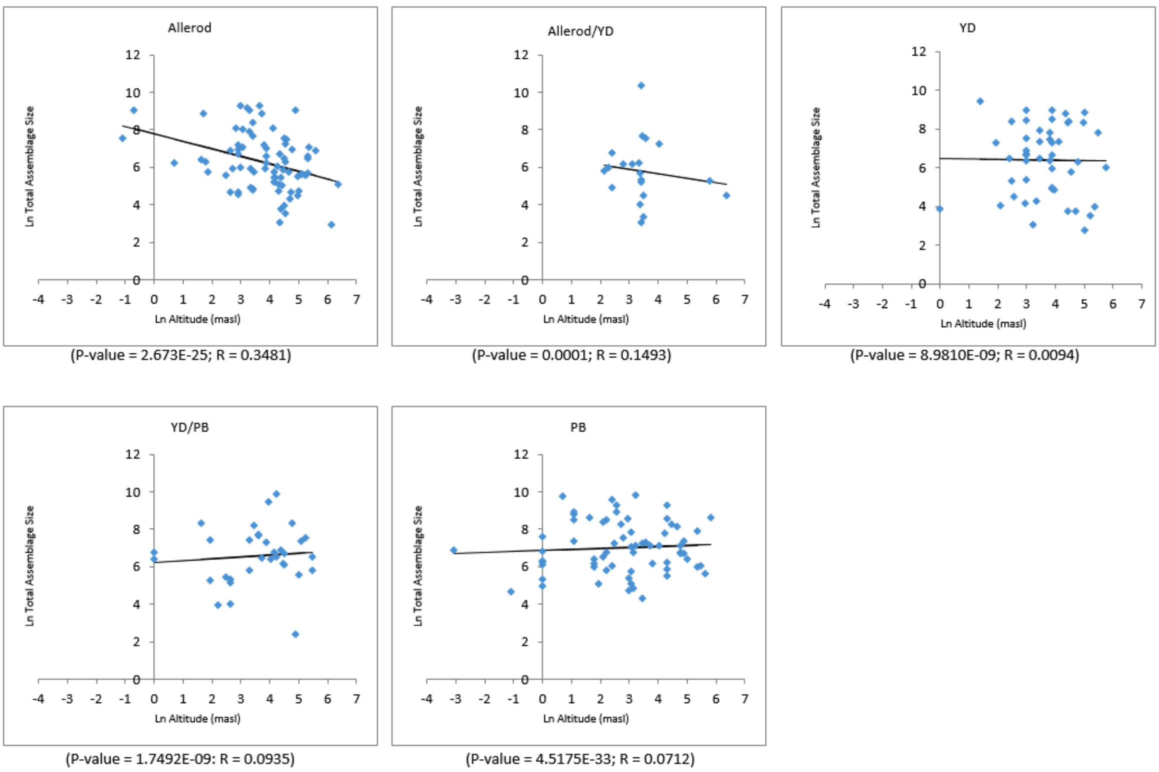
(Fig 3.35: Hunting tool assemblage size against altitude for the whole dataset. R = 0.147; p = 2.259E-32)



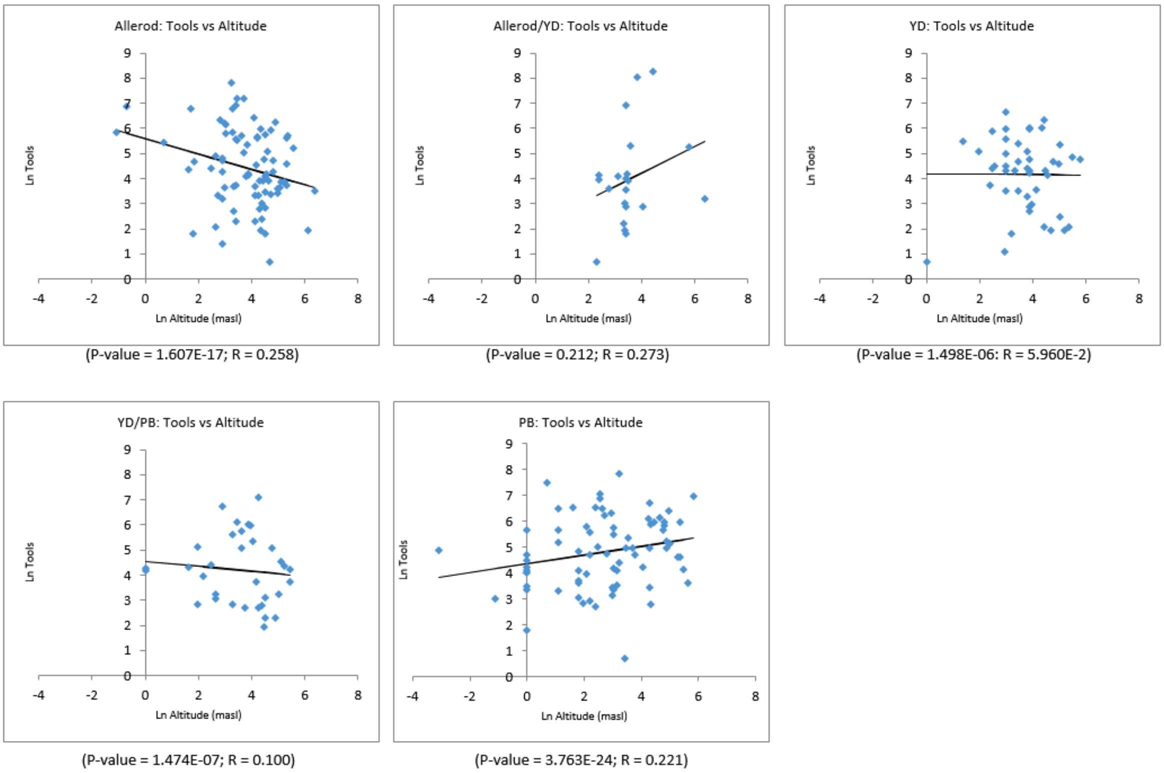
(Fig 3.36: Domestic tool assemblage size against altitude for the whole dataset. R = 0.009; p = 4.287E-44)

These results show no significantly strong evidence suggesting the numbers of tools, and their hunting and domestic components, are driven by altitude. There appears to be a possible, general, trend in lower numbers of tools and their domestic components with increasing altitude, which one might expect, but this trend also appears to be more pronounced in the hunting tool component, which is unexpected. In terms of this study, these results suggest any biases in the location of excavations, which may be controlled by the recent explosion in rescue archaeology, would not appear to have any significant effect on the numbers of tools found in an assemblage. However, the lack of any strong relationship also highlights the possibility of an interesting trend (or lack of) in significant differences in the numbers of hunting tools and domestic tools with altitude, which one might expect, especially in more logistically mobile populations. In fact, the evidence from the hunting tools might tentatively suggest hunting tools decrease in number to a higher degree as altitude increases.

This is the case when the whole dataset is analysed, but are there any significant changes seen in each climatic phase? The correlations for each of the phases are very weak, and show no strong evidence that altitude affects the number of artefacts in an assemblage in any one phase. However, there may be some potentially interesting patterns in both the total assemblage size and number of tools scatters (Figs 3.37, 3.38). The total assemblage size against altitude scatter (Fig 3.37) shows the Allerød and Allerød/YD transition show a more distinct negative correlation of decreasing numbers in the number of artefacts as altitude increases, while the YD displays no differences in the number of artefacts with increasing altitude, and the YD/PB transition and PB displaying a more positive correlation with slightly greater numbers of artefacts with increasing altitude. These patterns are similar for the Allerød, YD, and PB in the tools against altitude scatter, with the PB displaying a more distinct positive correlation, while the transitional phases are reversed with a positive correlation in the Allerød/YD transition and a negative correlation in the YD/PB transition. These patterns may tentatively suggest there is a gradual reversal of a negative trend in numbers of artefacts with increasing altitude in the Allerød, to a flat trend where there is no difference in the numbers of artefacts with increasing altitude, finally to a slightly positive trend of increasing artefacts with increasing altitude in the PB. There is a variable picture with the transitional phases seen in the number of tools hinting at brief changes in behaviour. However, this may be an effect of the notably small sample size for these phases.

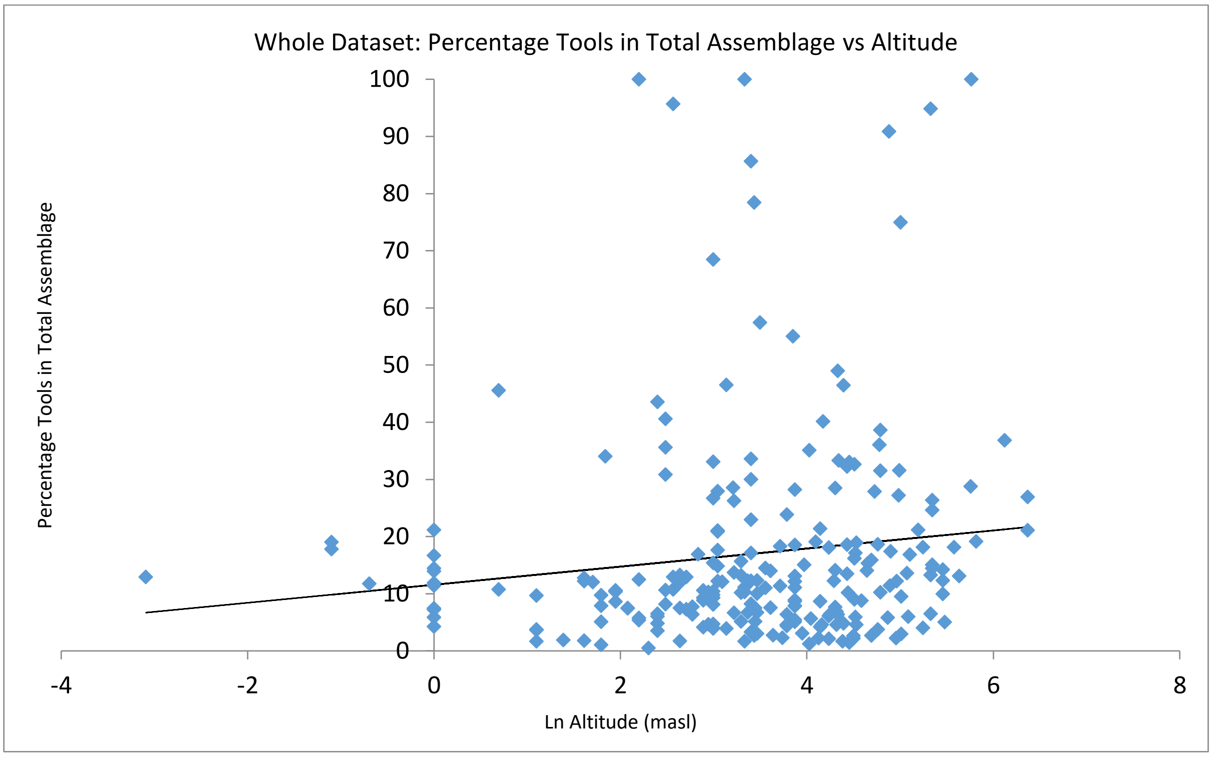


(Fig 3.37: Total assemblage size against altitude for each climatic phase)

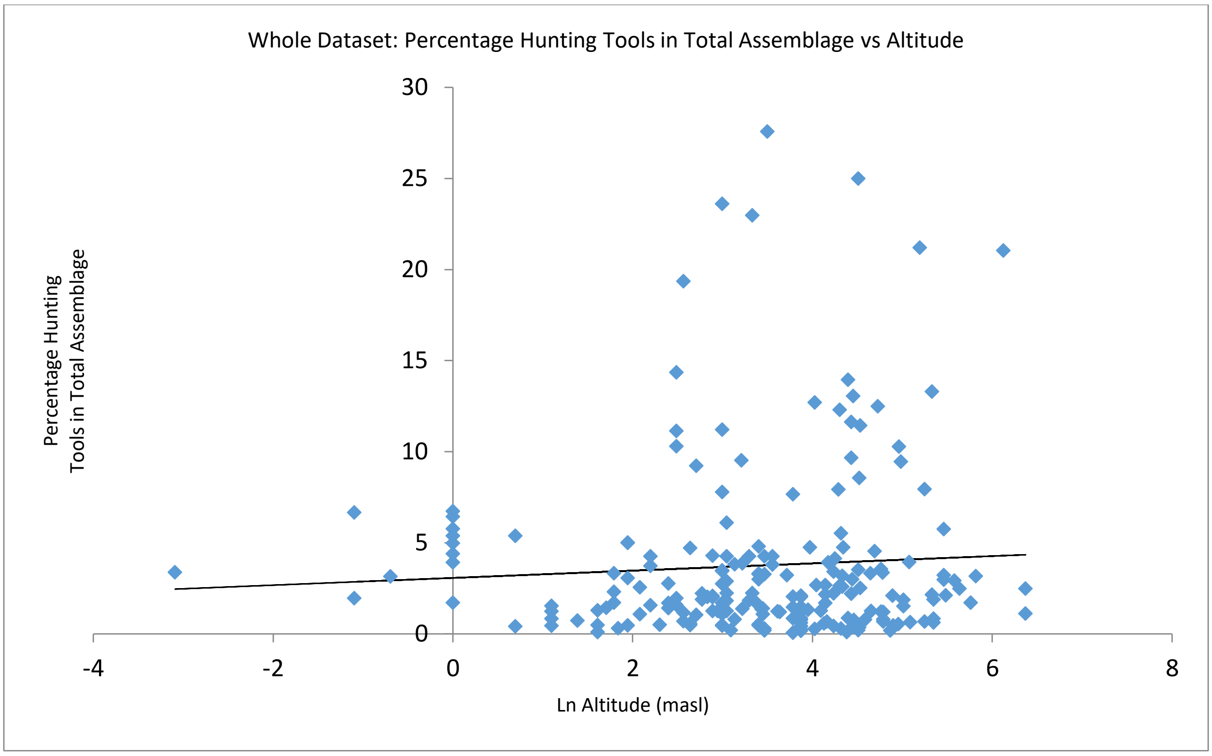


(Fig 3.38: Tools against altitude for each climatic phase)

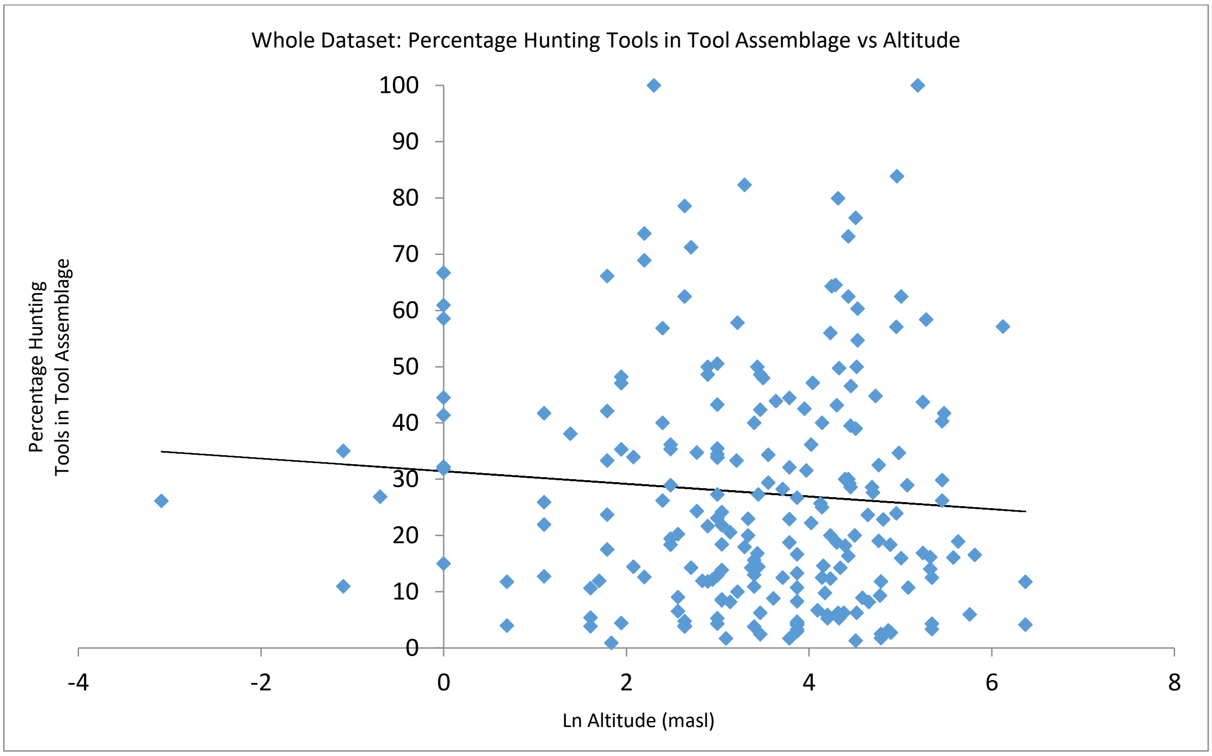
The above analyses focused on the total numbers of artefacts, but is there a relationship between the percentage of tools and their hunting and domestic components and altitude? One might, expect as altitude increases, the percentage of tools would increase as a result of increasing numbers of special task camps, which are associated with having larger tool components. This is partly supported when looking at the scatters for the percentage of tools in the total assemblage (Figs 3.39). However, the positive correlation is very weak and does not provide any evidence for a strong relationship between theses variables. The percentage of hunting tools would also be expected to increase with increasing altitude, which is somewhat supported when looking at the scatter for percentage of hunting tools in the total assemblage (Fig 3.40), but the opposite appears to be the case when looking at the percentage hunting tools in the tool assemblage (Fig 3.41), there being a slight negative correlation. Similarly, these correlations are very weak and these trends offer no strong evidence that altitude drives the percentage of hunting tools in an assemblage. However, the negative correlation seen in the percentage hunting tools in the tool assemblage might hint at unexpected behavioural patterns in terms of hunting tools in an assemblage. As for domestic tools, there are similarities with the percentage of tools and hunting tools in the total assemblage, which is unexpected. One might expect, higher altitude sites would be more frequently devoted to hunting activities with higher percentages of hunting tools. However, it appears this may not be the case as there is a distinct positive correlation in both the percentage of domestic tools in the total assemblage (Fig 3.42) and in the tool assemblage (Fig 3.43). Again, these correlations are very weak, suggesting there is no strong evidence altitude notably influences the percentage of domestic tools in an assemblage.



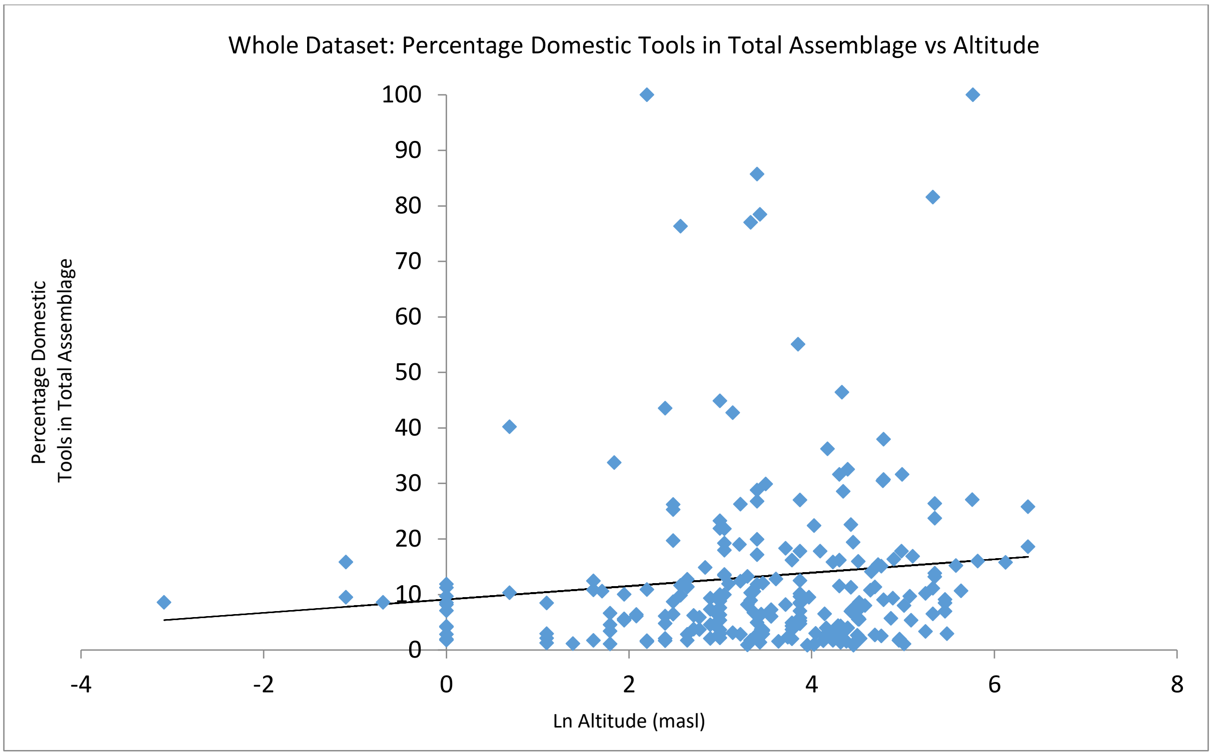
(Fig 3.39: Percentage of tools in the total assemblage against altitude. R = 0.126; p = <0.001)



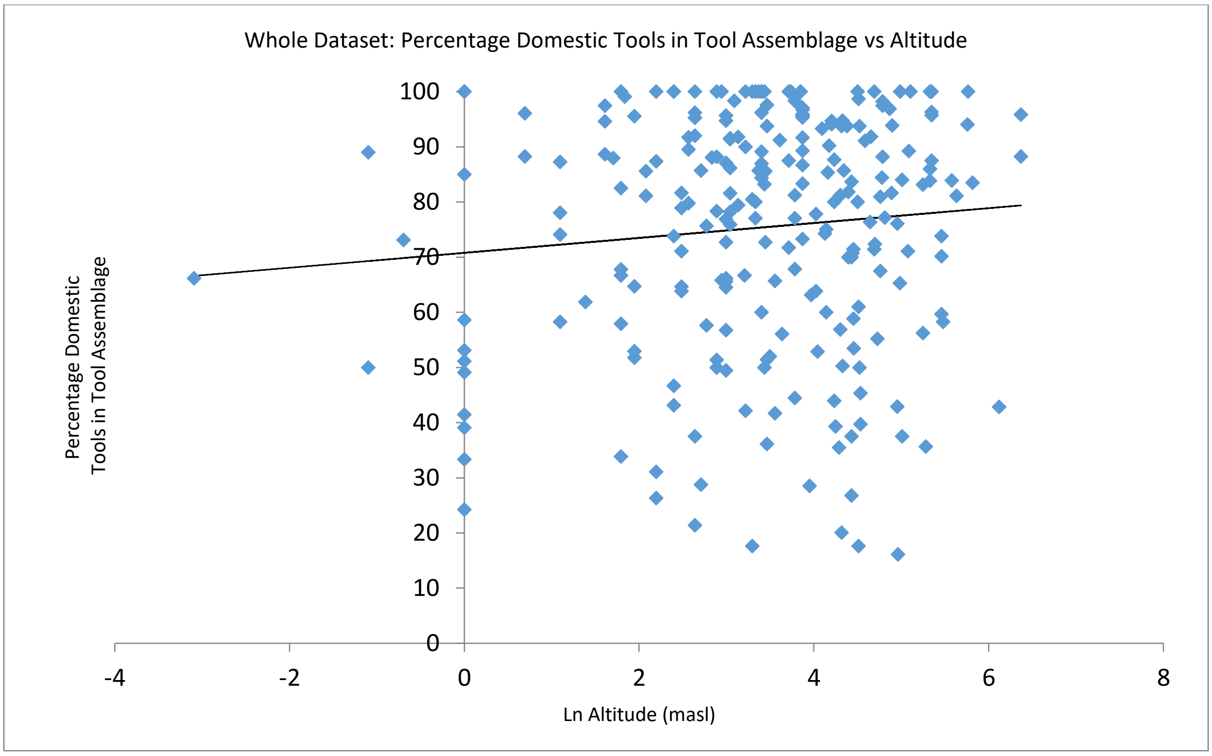
(Fig 3.40: Percentage of hunting tools in the total assemblage against altitude. R = 0.063; p = <0.001)



(Fig 3.41: Percentage of hunting tools in the tool assemblage against altitude. R = 0.080; p = <0.001)



(Fig 3.42: Percentage of domestic tools in the total assemblage against altitude. R = 0.112; p = <0.001)



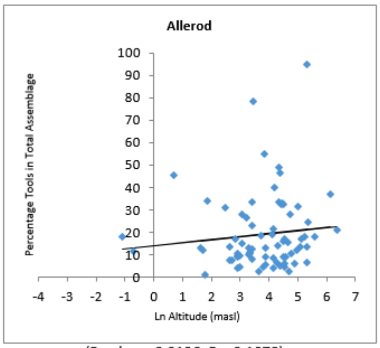
(Fig 3.43: Percentage of domestic tools in the tool assemblage against altitude. R = 0.094; p = <0.001)

When looking at the individual climatic phases, the evidence from the percentage tools suggest there is a more complicated picture (Fig 3.44). The Allerød displays a weak positive correlation, while the YD shows a weak negative correlation, and the PB has a weak, positive correlation. The Allerød/YD and YD/PB transitions have a weak positive, and weak negative correlation respectively. The percentage of hunting tools in the total assemblage (Fig 3.45) again display weak correlations, which increase with altitude in the Allerød, decreases in the YD, and increases again in the PB. Both the transitional phases have a weak negative correlation. However, the percentage hunting tools in the tool assemblage display different trends (Fig 3.46). The Allerød again has a weak positive correlation, but the YD also shows a weak positive correlation, while the PB displays a weak negative correlation. The transitional phase again displays a weak negative correlation.

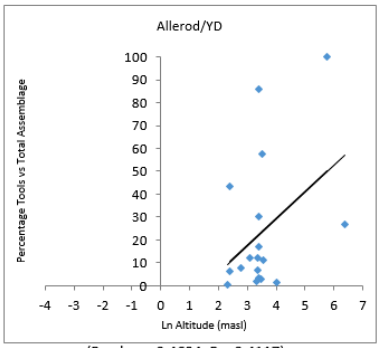
The percentage of domestic tools in the total assemblage (Fig 3.47), shows the Allerød and PB have weak positive correlations with altitude, while the YD has a weak negative correlation. The Allerød/YD has a weak positive correlation and the YD/PB has a weak negative correlation. When looking at the percentage of domestic tools in the tool assemblage (Fig 3.48) the Allerød and YD both have weak negative correlations with altitude, while the PB has a weak positive correlation. The Allerød/YD transition has a weak negative correlation and the YD/PB shows no change in the percentage of domestic tools with increasing altitude.

When comparing the percentage hunting tools to the percentage domestic tools we find, in the total assemblage, the Allerød and PB show a weak positive correlation for both hunting and domestic tools, hinting there may be a pattern of increasing percentages of both components with altitude in the total assemblage. The YD shows a negative correlation for both hunting and domestic tools, tentatively suggesting there is a decrease in both these components with increasing altitude in the total assemblage. Does this show a possible change in behaviour during the YD?

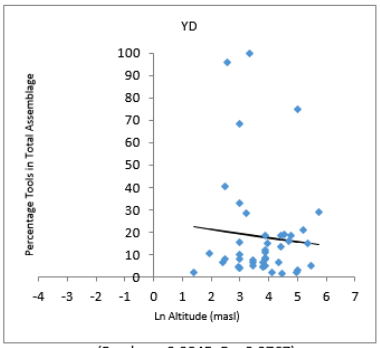
When comparing the percentage hunting tools with the percentage domestic tools in the tool assemblage there is a different pattern. The Allerød and YD both display a positive correlation in the percentage of hunting tools and a negative correlation in the percentage of domestic tools in the tool assemblage. The PB displays a positive correlation for both the percentage of hunting and domestic tools in the tool assemblage. Does this show a potential difference in behaviour during the PB? However, as all the correlations from the above graphs are very weak, there is no strong evidence to argue altitude has any influence on the percentage of tools and their hunting and domestic components. Any interpretations made from these scatters are purely hypothetical and cannot be supported statistically.



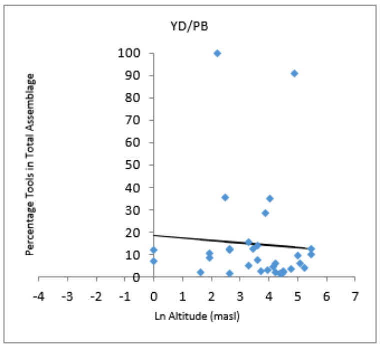
(P-value = 0.0196; R = 0.1078)



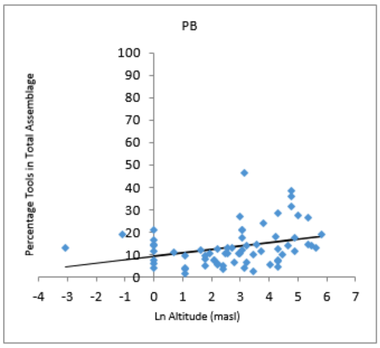
(P-value = 0.4694; R = 0.4117)



(P-value = 0.0845; R = 0.0767)

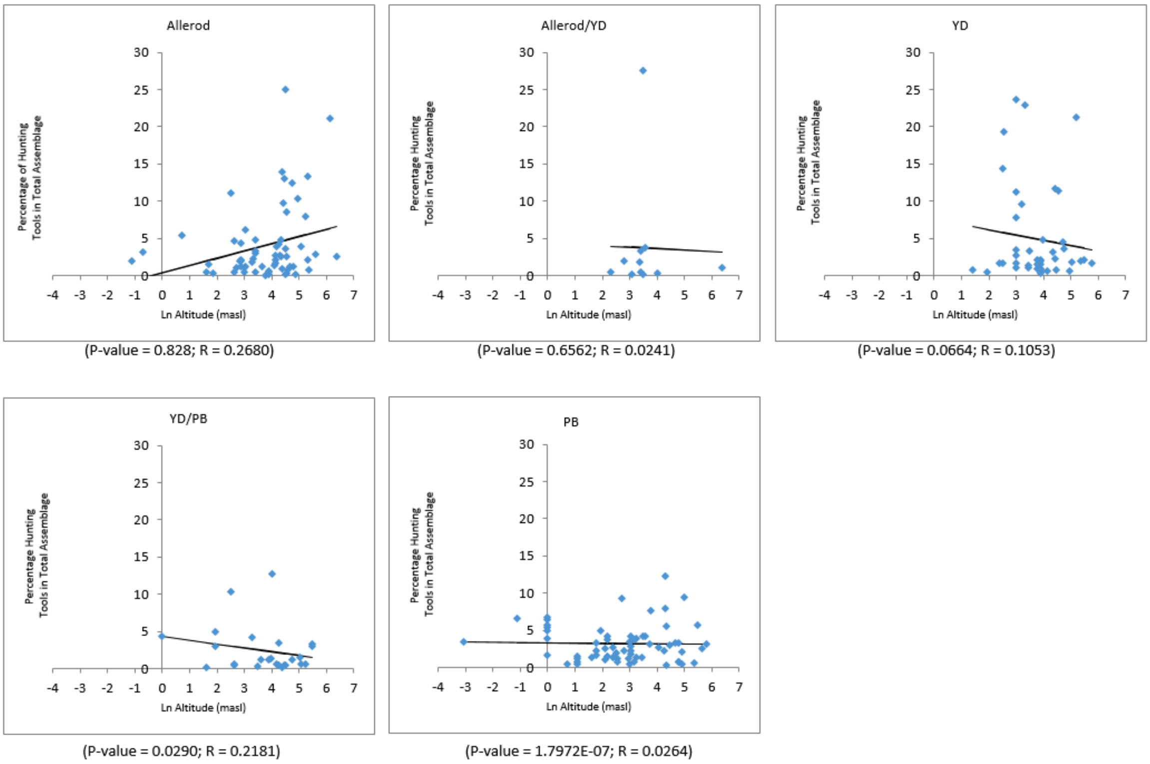


(P-value = 0.1070; R = 0.0642)

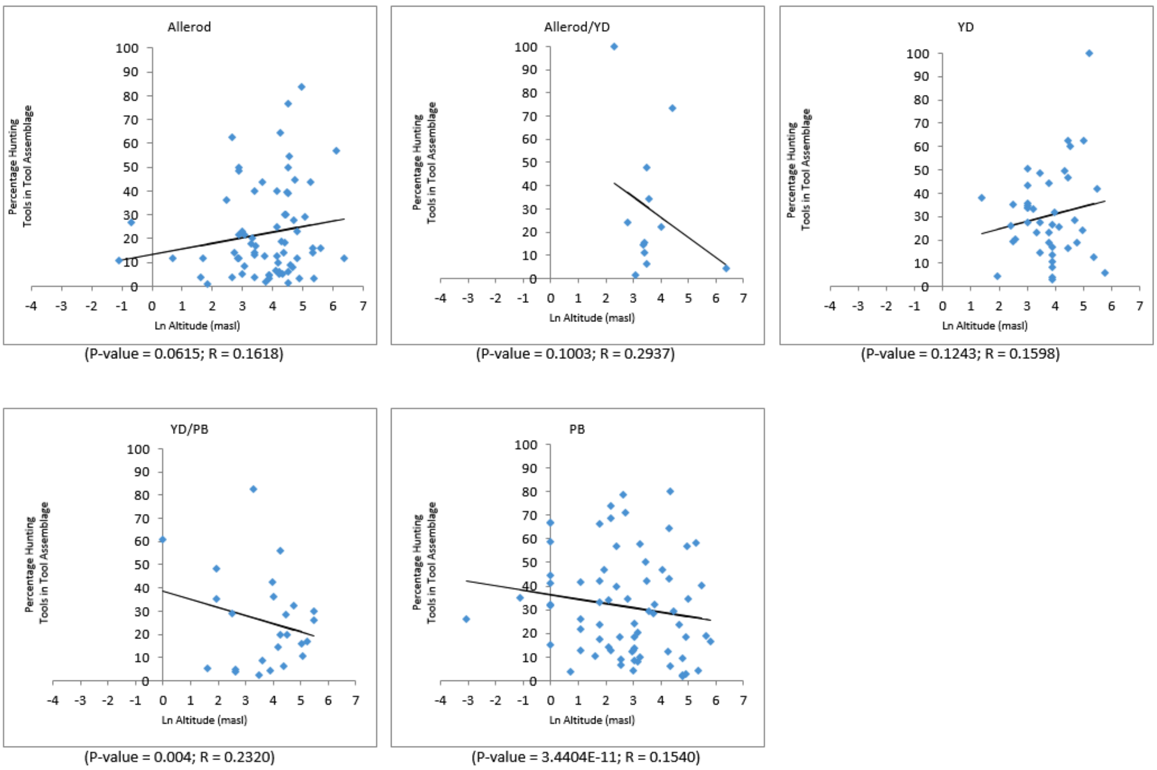


(P-value = 5.55992E-06; R = 0.3127)

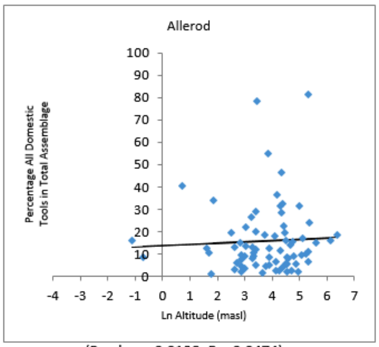
(Fig 3.44: Percentage of tools in the total assemblage against altitude for each climatic phase)



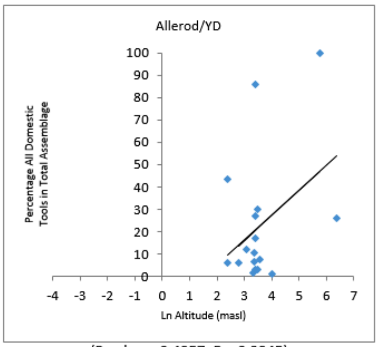
(Fig 3.45: Percentage of hunting tools in the total assemblage against altitude for each climatic phase)



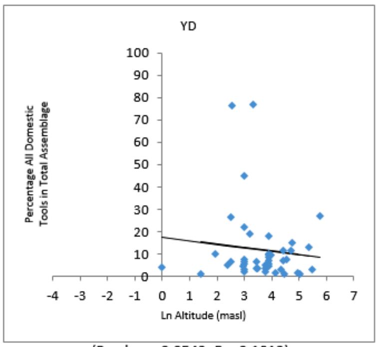
(Fig 3.46: Percentage of hunting tools in the tool assemblage against altitude for each climatic phase)



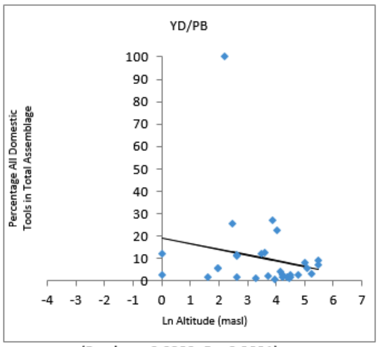
(P-value = 0.0138; R = 0.0474)



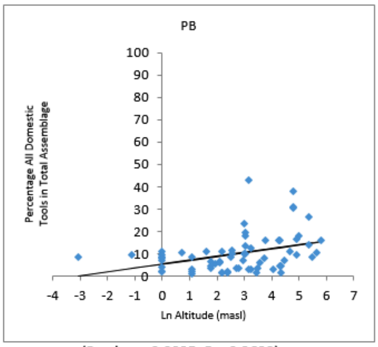
(P-value = 0.4957; R = 0.3945)



(P-value = 0.0542; R = 0.1013)

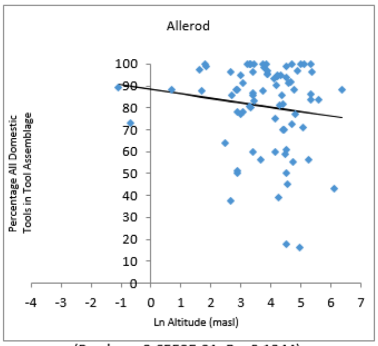


(P-value = 0.0392; R = 0.2031)

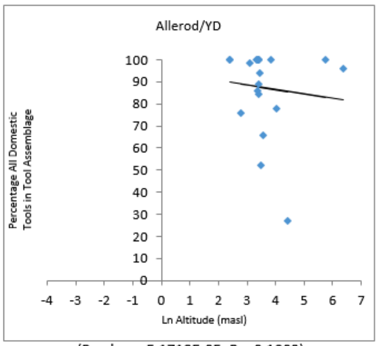


(P-value = 0.0035; R = 0.3699)

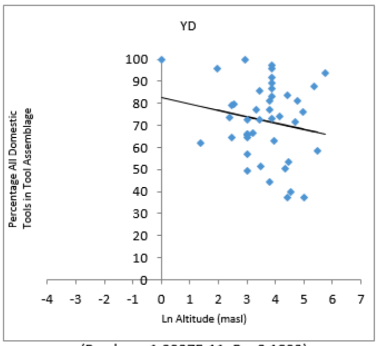
(Fig 3.47: Percentage of domestic tools in the total assemblage against altitude for each climatic phase)



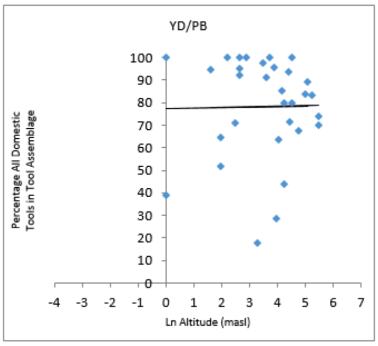
(P-value = 9.6559E-21; R = 0.1344)



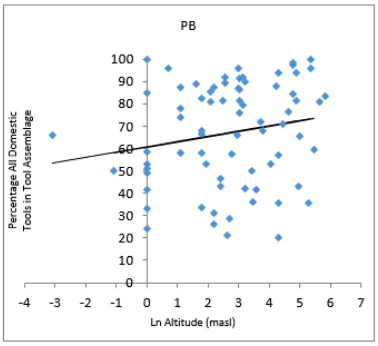
(P-value = 5.1718E-05; R = 0.1009)



(P-value = 1.2237E-11; R = 0.1822)



(P-value = 9.9462E-08; R = 0.0161)



(P-value = 4.7801E-20; R = 0.1880)

(Fig 3.48: Percentage of domestic tools in the tool assemblage against altitude for each climatic phase)

Overall, there is no strong, statistical, evidence there is any relationship between the location in the landscape of sites (in terms of altitude) and the number and percentage composition of artefacts. This might be surprising as one might expect there to be distinct differences in composition of sites from lowlands to uplands, especially if there was a distinct logistical strategy employed. Despite this lack of strong evidence for hunter-gatherer behavioural change, it can be said any biases in the choice of excavation location will have little effect on the results of this study.

3.4 - Conclusions

In conclusion, it can be said that most assemblages are from excavations carried out from 1950 onward, most notably in the 1980's and 1990's. This provides a strong level of confidence in any results produced from this study as the vast majority of sites were excavated from excavations that are widely considered to be more informed in terms of excavation techniques, recording, and publication. However, there are disparities within each individual period, which may cause some problems. The Allerød and PB phases both have the largest proportions of assemblages from sites excavated post-1980 in their respective periods, while in the YD the majority of reported assemblages are from excavations between 1940 and 1980. This means the YD has a larger component of less modern excavations, which one could argue causes a mismatch for direct comparison in terms of excavation techniques. This is an issue which cannot be resolved, but must be taken into account when interpreting results.

Importantly, it was found there is no strong evidence suggesting the total number of artefacts and the percentage of tools, blanks, and cores, are significantly affected by excavation date. Therefore, there is confidence that excavation date should not drive the results of analysis. Larger excavations seem to be carried out in the 1950's, while a larger number of smaller sites appear to be carried out post-1990. This is probably a result of a focus on rescue archaeology in more recent times. However, there is no strong correlation in trends in the size of excavations and excavation date, and should not pose a problem for analysis.

When looking at site types, the majority of lithic assemblages, excavated pre-1940, are from caves. This bias is in contrast to more modern excavations in which the vast majority of lithic assemblages, excavated post-1950, are from open-air sites. This may be due to; the greater interest in smaller, less impressive sites in modern research; the fact that rescue excavations have been increasingly more frequent in recent years; and possibly due to the fact that many of the cave sites that contain lithic assemblages have already been found and excavated in the late 1800's and early 1900's and overlooked and/or not recorded, leaving few known pristine caves with intact lithic assemblages left to study. The assumption is the earlier excavations were not as thorough and professional as modern excavations and did not record artefacts as reliably. It was found, the majority of earlier excavations did not record waste material, and it is also assumed that blanks would have been less important to record. However, the total number of lithic artefacts do not appear to change significantly in cave sites from the late 1800's and early 1900's to those from more recent cave excavations, suggesting that cave sites have a particular lithic composition in which waste material is naturally low at cave sites. Perhaps the fact that lithic waste material is rarely reported in early excavations may be due to the majority of excavated sites that contain lithic assemblages being cave sites, which lack significant quantities of manufacturing debris. There is also another anomaly, in that, the majority of cave sites with lithic assemblages are from the UK and Belgium. It is unclear if this is a research tradition bias, the nature of the geology of these regions, where caves are more abundant, or different behavioural patterns in hunter-gatherer populations.

The B/T, B/C, and T/C ratios form an important part of the methodology in which to analyse changes in tool assemblage composition. Consequently, it was felt prudent to test if there was any effect on excavation date on these artefact ratios. The assumption would be that earlier excavators did not find artefacts such as blanks and cores important to record, and focussed mainly on tools. If this assumption is correct, then one would expect, the B/T, B/C, and T/C ratios to be significantly affected by excavation dates. However, this appears not to be the case, with no strong correlations between any of these variables. However, there is a weak correlation between the B/T ratio and excavation date which might raise some concern, and thus it has been decided to eliminate sites excavated pre-1960 in order to minimise any errors this may cause.

Site size/excavation area was also recognised as a potential source of error, but there is only a weak positive correlation with the total number of artefacts that does not provide strong evidence site size/excavation area should significantly drive results. This is the same for both the number and percentage of tools, hunting tools, and domestic tools, which also show weak correlations. This is a surprising result as it was expected larger sites would have a significantly larger number of domestic tools, indicating larger residential bases, while smaller sites would have a larger number of hunting tools representing small, short-term hunting camps. This does not appear to be the case.

Similar results were found between altitude and numbers and percentages of tools, hunting tools, and domestic tools. It was expected, with increasing altitude, there should be increasing numbers of hunting tools and decreasing numbers of domestic tools. This would represent an increase in special task, hunting camps at higher elevations. This again appears not to be the case in northwest Europe.

When testing the relationships between excavation date, site size/excavation area, and altitude, there appears to be no strong and significant trends between any of the proposed variables, which may drive the results of this study. There is a potential problem with the representation of cave sites and open-air sites, which appear to be biased to the research culture of the time (i.e. cave sites in the early 1900's, open-air sites in the 1990's-2000's), but this is not a problem that can be resolved within this study, and it is considered not to be a major source of error. Overall, it is considered that the data collected in this study is robust enough to confidently state that there is minimal interference from external factors not related to hunter-gatherer behaviour that will influence the results presented in the following chapters. The next chapter will present the results of the analysis for the northwest European dataset.

Chapter 4: Northwest Data Analysis

Chapter 1 described the climatic changes that occurred during the Pleistocene/Holocene Transition, and Chapter 2 described theoretical models of hunter-gatherer mobility, and set out predictions based on these theoretical models. Lithic assemblage data was then collected from two regions in Western Europe; a main north-western European dataset and a smaller southern European dataset for comparison (see Appendix 2). These datasets were critically examined in Chapter 3 in order to assess the reliability of the data and attempt to minimise potential sources of error. This chapter will now present the results of the analysis of the north-western European dataset. Potential tool assemblage indicators were identified in Chapter 2 in order to monitor possible changes in mobility. However, not all were suitable for this analysis due to the constraints of the data. The suitable indicators for this study are set out in Table 4.1, while the definitions of tool classes used in this study are presented in Appendix 1 pg. 305 (Glossary of Tool Definitions).

This chapter will present the results of the analyses set out in Table 4.1. Firstly, the individual indicators, for each climatic phase, will be assessed and statistically compared in order to observe the general level of residential/logistical mobility employed during the Allerød, YD, and PB. These results will be presented within key topics relating to hunter-gatherer mobility, discussed in Chapter 2: tool diversity, tool expediency, and raw material use. Secondly, a new set of theoretical tool assemblage characteristics for base camps and special task camps will be proposed and checked against each assemblage within each database. It is hoped this will give an idea as to the numbers of base camps and special task camps in each climatic period, thus further helping to ascertain the levels of residential and logistical mobility.

	Indicator	Method of Analysis	Logistical	Residential
Diversity	Richness	NTAXA	Lower	Higher
	Evenness	Simpson's Index	Lower	Higher
	Complexity	Percentage of microliths	Higher	Lower
	Artefact density	Artefacts per m^2	Higher	Lower
		Site/excavation size	Lower	Higher
Expediency	Proportion of formal and expedient tools	Blank to tool ratio	Higher	Lower
		Blank to core ratio	Higher	Lower
		Percentage of utilised and retouched blanks	Higher	Lower
	Tool maintenance	Percentage of chips	Lower	Higher
	Raw material economy	Tool to core ratio	Lower	Higher
Raw Materials	Proportion of local vs non-local materials	Data on raw material provenance	Local	Non-local
	Site distance from materials	Blank to tool ratio	Higher	Lower
		Blank to core ratio	Lower	Higher

(Table 4.1: Expected indicators for changes in mobility and methods of analysis)

4.1 - Tool Diversity Indicators

In order to compare and contrast the level of diversity within the tool assemblages from each climatic phase, the mean values of each variable were calculated for each period and then compared statistically firstly using Kruskal-Wallis test followed by post-hoc tests using the Mann-Whitney U test, and Dunn's test with Bonferroni correction. Statistical analysis was carried out using R.

Within this study, diversity is referred to as the interrelationship between richness (NTAXA) and evenness. An assemblage with a high richness may be unevenly represented by certain tool types and thus, would be less diverse than a rich assemblage that was evenly represented. Due to this a "diverse" or "generalised" assemblage would be classified here as having a high richness and a high evenness. In contrast, a less diverse or specialist assemblage would have a low richness and a low level of evenness.

It is expected a more logistical strategy would display, on average, a more specialised tool assemblage, representing a higher number of special task camps, with lower evenness values. Richness is complicated by the tool groupings in this study. It is generally accepted richness should be higher in a logistical strategy, representing a greater number of specialised hunting tools for a greater number of specialised tasks. However, it is considered here that distinguishing between different functions of hunting tools is too subjective (at least from the available data, which generally lacks information on hafting). As such, there are only two tool types considered to be "hunting tools" in this study; points and microliths. Thus, a purely hunting based camp would appear to have low richness with a maximum of two tool types. With this in mind, it might be expected, on average, richness values should be lower in more logistically mobile populations.

Density of artefacts within an assemblage/excavation area is expected to be, on average, higher in logistically mobile populations, representing a higher number of special task camps with fewer total number of artefacts, but distributed within a much smaller area than a larger base/residential camp. Base/residential camps are expected to have a greater number of total artefacts, but these artefacts would be distributed over a much larger area. To give an example, a residential site with 10,000 artefacts distributed over an area of 500m^2 would be considered a large site with a density of 20 artefacts per m^2, while a hunting camp with 200 artefacts distributed over an area of 5m^2 would be considered to be a small site but have a density of 40 artefacts per m^2.

The number of tool components is again assumed to be indicated by the percentage of microliths within the assemblage.

4.1a - Analysis of Richness (NTAXA)

A Note on Richness

Before continuing with the analysis, one issue became apparent regarding diversity. The definitions of diversity set out in Chapter 2 rely on the principle that specialist hunting toolkits comprise multiple projectile points, each with specialist functions. Hence, less mobile populations operating in a more logistical system are seen to have a higher richness in their toolkits. This is a logical conclusion when tool function can be definitively recognised. However, in prehistoric contexts, this is difficult to apply and is not always possible and is accentuated by the fact that published reports rarely provide the required information on hafting of the projectile points, which could provide a more reliable identification of specialist functions of certain projectile types. Due to this, a decision was made to classify all projectiles into two simple categories "points" and "microliths" in order to eliminate the subjectivity of assuming morphologically/culturally different points having different functions, which is not always the case. This classification then changes the expected richness in logistical systems. Instead of having a higher diversity, one would expect, on average, a lower diversity, especially in hunting camps which may contain little else but points. This is only expected to affect the richness values as evenness calculates the spread of tools in an assemblage. It is expected there would still be a lower level of evenness in logistically mobile populations representing the dominance of hunting tools in hunting camps.

Another problem is the issue of assuming all logistical camps are hunting camps, while specialist "domestic" camps being largely ignored in the literature.

The calculations of the richness values, used here, are borrowed from biological ecology with NTAXA representing the numbers of individual lithic tools rather than the number of different faunal species. The results of the mean number of tool types in each climatic phase follows:

Results

Table 4.2 shows the results of the mean number of lithic tool types (NTAXA) in assemblages from each climatic phase and their transitions.

	μ	**n**	**σ**	**σ^2**
Whole Dataset	7.475	245	2.394	5.730
Allerød	7.444	79	1.948	3.795
Allerød/YD	6.387	21	3.377	11.403
YD	6.847	45	1.744	3.041
YD/PB	7.134	30	1.499	2.247
PB	8.270	70	2.313	5.349

(Table 4.2: Comparison of the weighted mean values of richness (NTAXA) for each climatic phase and their transitions)

As with each set of data, statistical analyses were preformed using R, using the Kruskal-Wallis rank sum test, Man-Whitney U test, and Dunn's test (with Bonferroni correction) and are presented in A3.1 in Appendix 3.

Analysis

When comparing the mean values of the NTAXA (number of tool types), no statistically significant differences between any of the climatic periods were found (Kruskal-Wallis rank sum test: ($H(2) = 2.046$, $df = 2$, p-value = 0.360), suggesting the number of tool types do not change significantly from the Allerød to the YD, the YD to the PB, and between the Allerød and PB. This might be unexpected as if there are shifts to more logistically (specialist) or residentially (generalist) mobile groups one would expect a change in the number of different tool types: an increase in tool types into more logistically mobile populations and a decrease into more residentially mobile populations. However, there is one flaw in the data recorded here, in that there are only two tool types recognised as hunting tools (points and microliths). These groupings were defined as such, in this study, to minimise the subjectivity of defining different morphological point types to different functions with the information made available in a large proportion of publications from which the data was collected. Therefore, these results might not be expected to be significant as it is more likely all the basic tool classifications were present in every period. However, one could argue, assuming the tool classifications defined here, in more logistical populations there should be a lower level of richness, representing the increased presence of hunting camps with less domestic tool types. If this is assumed, there is a suggestion this may be the case during the YD, which has the lowest mean richness values. This might tentatively suggest a shift to a more logistical strategy during the YD compared with the Allerød and PB. However, the PB has a notably higher variance, which might suggest a distinctly greater variation in the number of tool types from site to site. This would be expected in a more logistical system where less tool types are expected in special task camps and more tool types in base camps. In contrast, one would expect, in a residential system, there would be less variation from one site to the next.

4.1b - Analysis of Evenness

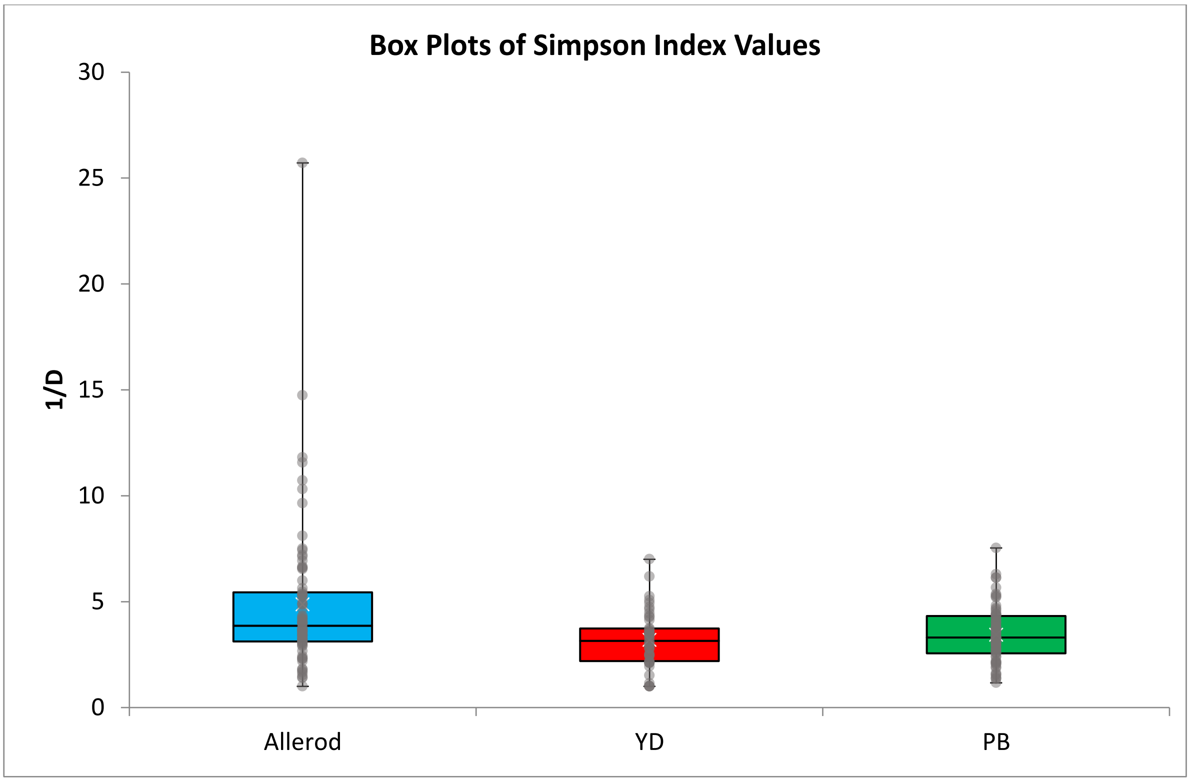
Simpson Index Calculations

Analysis

The lowest possible Simpson Index value is 1, which would represent the total dominance of the assemblage by a single tool type. Therefore, the larger the value the greater the level of evenness of the assemblage. The Simpson Index lays greater emphasis on the evenness component and on the dominant [cover] types (Nagendra 2002). The results are presented in Table 4.3 and Fig 4.2, and statistics presented in A3.2 in Appendix 3.

	μ	**n**	**σ**	**σ^2**
Whole Dataset	3.859	244	2.452	6.013
Allerød	4.869	78	3.526	12.430
Allerød/YD	3.380	21	1.815	3.293
YD	3.191	45	1.357	1.841
YD/PB	3.664	30	1.875	3.517
PB	3.441	70	1.338	1.790

(Table 4.3: Comparison of the mean values of evenness (Simpson Index) for each climatic phase and their transitions)



(Fig 4.2: Box plots of the Simpson Index data presented in table 4.3, showing the mean (x), and including data point distribution)

There was found to be a significant relationship between the periods (Kruskal-Wallis rank sum test: (H(2) = 13.332, df = 2, p-value = 0.001) with the mean values of the Simpson Index showing significant differences between the Allerød and the YD (p=0.001) and the Allerød and PB (p=0.005). There is a large, significant, decrease in the mean Simpson Index values from the Allerød to the YD but the PB mean values are much smaller than the Allerød, which suggests there was not as a significant return to the same levels of the Allerød. This is somewhat surprising as it would be assumed the interstadial periods would have roughly similar values. This suggests there was a distinct and significant decrease in evenness during the YD from the Allerød which indicates a more specialised, and likely logistical mobility strategy, was employed during the YD. However, there is no evidence for a return to a more even level of evenness from the YD to the PB, which suggests there was no change to a more residentially mobile system during the PB.

These results provide strong evidence of a shift to a more logistical system during the YD that might be related to climate change. However, there is no significant difference in evenness between the YD and PB, indicating there was no increase in levels of residential behaviour during the PB as would be expected. As the Allerød and PB are both warm interstadial periods, one would expect these periods to have similar characteristics in their tool assemblages. This might be a result of the documented, unstable, climatic conditions of the PB preventing the same level of residential mobility adopted in the Allerød and extending the YD strategies into the Holocene.

However, there is a distinctly larger variance in the Allerød dataset, suggesting there was a distinctly greater variation in evenness between assemblages. This might be expected in a more logistical strategy with special task camps having lower levels of evenness and base camps having higher levels of evenness. In a residential system, one might expect the variation from site to site would be low.

4.1c - Analysis of Density

The assemblages from the YD generally appear to have a lower level of richness and evenness, indicating a more logistical system was in place during this period, compared with the Allerød and PB (and especially the Allerød). This generally seems to correlate with the climatic changes in and out of the YD, although the PB may prove to be more complex. Thus, if this interpretation is assumed to be true, then the density of assemblages should on average be higher during the YD, reflecting the greater number of small special task camps and fewer, large, base camps. With the information available, only two measures for density were found to be suitable; Artefacts per m^2 and the total number of artefacts within an assemblage.

Total Number of Artefacts per m^2

Analysis

Here the total number of artefacts are represented by the combined total number of blanks, tools, and core in assemblages. This is due to the fact the reporting of chips, waste, and debris is highly variable and thus an unreliable measure. Hence, from now on, when the total number of artefacts or total assemblage is discussed, it refers to the combined total of blanks, tools, and cores. The results are presented in Table 4.4 and statistics presented in A3.3 in Appendix 3.

	μ	n	σ	σ^2
Whole Dataset	44.124	147	127.224	16185.898
Allerød	20.620	45	36.526	1334.179
Allerød/YD	25.199	14	40.069	1605.516
YD	64.391	31	126.895	16102.322
YD/PB	27.455	16	54.469	2966.904
PB	67.565	41	205.330	42160.274

(Table 4.4: Mean density (per m^2) in the total assemblage for the whole dataset and each climatic phase)

Results

There appears to be a large increase in the mean density of artefacts per m^2 between the Allerød and the YD with the PB having a similar mean density to the YD. However, this dataset provides no evidence these differences are significant between any of the periods (Kruskal-Wallis rank sum test: ($H(2) = 2.163$, df = 2, p-value = 0.339). This is most likely due to the large standard deviations and variances of the YD and PB. The higher densities of the YD and PB assemblages may tentatively suggest populations during these periods practised a greater level of logistical mobility compared with those during the Allerød, although no firm interpretations can be made. Interestingly, the PB has a slightly higher mean density than the YD, indicating the warmer conditions of this period did not facilitate a return to sites with a similar mean density as the Allerød. This would indicate, if we assume these differences are real, they are not strongly related to climate change, or, again, the unstable conditions of the PB had a significantly different effect on human population's mobility.

It could be argued the larger standard deviations and variances of the YD and PB suggest a much larger variation in site types with different intensities of occupation. This might indicate a more logistical system with base camps with lower densities, and logistical camps with higher densities, during the YD and PB. Thus, this may indicate populations during the Allerød may have practised a more residential strategy with distinctly less variation in artefact density from site to site.

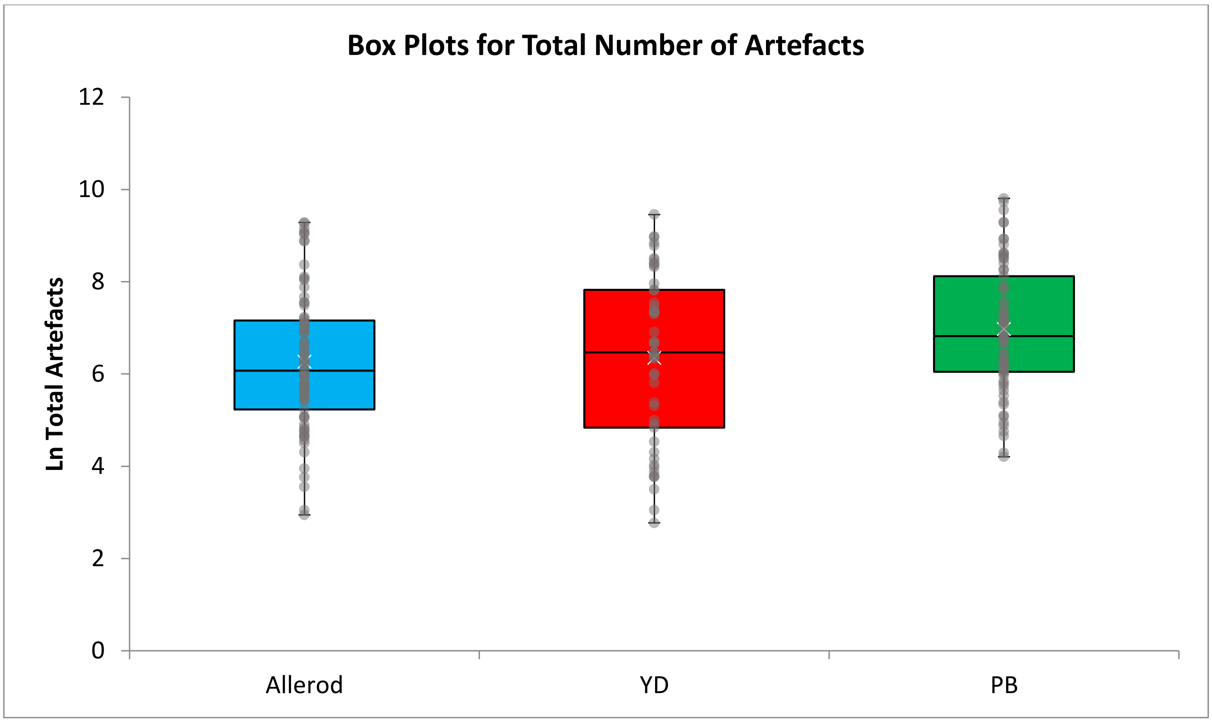
Total Number of Artefacts

The mean densities per m^2 of the YD and PB appear to be much larger than the Allerød (although not statistically significant). Suggesting the YD and PB had greater levels of logistical behaviour. The diversity data also suggests the YD and PB have greater levels of specialisation, indicating a more logistically mobile system, compared with the Allerød. However, the YD shows the greater levels of specialisation of the three periods. If these trends continue, one would also predict there should be a greater number of total artefacts during the Allerød, and possibly the PB, representing a greater number of larger sites that would be expected in more residentially mobile populations. Conversely, one would predict a lower total number of artefacts during the YD representing a greater number of smaller, logistical camps than larger base camps. The results are shown in Table 4.5 and Fig 4.3, and statistics presented in A3.4 in Appendix 3.

Analysis

	μ	n	σ	σ^2
Whole Dataset	2038.286	248	3668.293	13456374.640
Allerød	1581.922	77	2666.936	7112545.994
Allerød/YD	2033.950	20	6826.284	46598149.520
YD	1950.633	49	2723.366	7416721.279
YD/PB	2015.576	33	3909.458	15283862.880
PB	2621.928	69	3859.262	14893904.070

(Table 4.5: Mean number of total artefacts for the whole dataset and each climatic phase)



(Fig 4.3: Box plots of the total artefact data presented in Table 4.5, showing the mean (x), and including data point distribution)

<u>Results</u>

The results indicate there is a statistically significant relationship in the total number of artefacts (Kruskal-Wallis rank sum test: (H(2) = 7.640, df = 2, p-value = 0.022), with the PB having a significantly larger mean number of lithic artefacts than the Allerød (p=0.004). However, there is no significant difference found between the Allerød and YD. This might suggest there was a lower level of mobility practised during the PB, compared with the Allerød. This dataset might indicate there was a continued increase in the numbers of blanks, tools, and cores from the Allerød, through to the PB, which might suggest an increase in the number of larger sites through time and thus an increase in residential mobility. However, the PB again has an extremely large standard deviation and variance, which might suggest a large variation in site types/size/densities.

4.1d - Analysis of the Percentage of Microliths

The level of complexity is hard to quantify from this dataset. Information on hafting techniques were not widely available. Hence, it was decided to use the number of microliths as an indicator as this tool type shares many of the expected characteristics of a component of a more complex tool manufacturing strategy. Assuming higher numbers of microliths can be equated with higher levels of tool complexity, and from the general trend of the results, if a more logistical strategy was employed during the YD one would predict a higher percentage of microliths during the YD representing a higher level of complexity.

It was decided to produce two sets of results, one from the percentage of microliths in the total assemblage (Table 4.6, with statistics presented in A3.5 in Appendix 3), and one from the percentage of microliths in the tool assemblage (Table 4.7, with statistics presented in A3.6 in Appendix 3).

Analysis

Total Assemblage

	μ	n	σ	σ^2
Whole Dataset	0.556	248	1.109	1.229
Allerød	0.044	77	0.128	0.016
Allerød/YD	0.017	20	0.130	0.017
YD	0.336	49	0.707	0.500
YD/PB	0.141	33	0.645	0.417
PB	1.291	69	1.460	2.132

(Table 4.6: Weighted mean percentage of microliths in the total assemblage for the whole dataset and each climatic phase)

In Tool Assemblage

	μ	n	σ	σ^2
Whole Dataset	10.573	261	21.051	443.130
Allerød	0.296	82	0.766	0.587
Allerød/YD	31.182	24	36.060	1300.310
YD	5.016	46	8.782	77.120
YD/PB	1.721	34	5.938	35.256
PB	14.825	75	18.918	357.894

(Table 4.7: Weighted mean percentage of microliths in the tool assemblage for the whole dataset and each climatic phase)

Again, the Allerød/YD period includes the site of Camp d'Auvours, which is not representative of the sample. If this site is excluded the mean is 0.133, standard deviation is 0.827, and variance is 0.684, which is again more in line with the results of the Allerød.

Results

The results of the percentage of microliths in the total assemblage and tool assemblage both show a significant relationship (Kruskal-Wallis rank sum test: ($H(2) = 56.341$, df = 2, p-value = <0.00001; and $H(2) = 64.822$, df = 2, p-value = <0.00001) with a continued significant increase from each period from the Allerød, to the YD ($p=0.0002$; $p=<0.00001$), and to the YD to the PB ($p=0.0002$; $p=0.001$). The percentage is notably much greater during the PB. If microliths are assumed to be a measure of complexity, then the YD has an increased level of complexity compared with the Allerød, while the PB has a distinctly higher level of complexity compared with the YD and Allerød. This indicates there is a continually increasing level of logistical mobility, with the PB having a much higher level of logistical behaviour. This seems unlikely when looking at all the above analyses. Perhaps microliths are a poor indicator for complexity? This trend also suggests the level of complexity/percentage of microliths is not related to climate change, rather another factor, most likely cultural change.

4.2 - Tool Expediency and Raw Material Indicators

Using the definitions of expediency set out in Chapter 2, it is expected less mobile populations within a logistical settlement system would show greater characteristics of an expedient manufacturing strategy (i.e. a greater proportion of quickly manufactured, more disposable, tools), while more mobile populations within a residential settlement system would show greater characteristics of a formal manufacturing strategy (i.e. a greater proportion of curated, formalised tools). Using only data obtained from the inventories of lithic assemblages, the most likely indicators of levels of expediency/formality would be the B/T and B/C ratios, along with the percentage of retouched and utilised blanks in an assemblage.

If these predictions are accepted, then a more expedient manufacturing strategy might be expected to have:

1) A higher blank to tool ratio, possibly indicating a greater importance on producing blanks over tools, which in turn may indicate the possible preference of using blanks as tools.
2) A higher blank to core ratio, possibly indicating a greater number of blanks struck from cores that were likely utilised without extensive formal modification.
3) A higher percentage of retouched/utilised blanks, indicating the greater use of unmodified blanks for tasks.

Conversely, a more formal manufacturing strategy might be expected to have:

1) A lower blank to tool ratio, possibly indicating a greater importance on producing formalised tools from blank production.
2) A lower blank to core ratio, possibly indicating a greater number of blanks struck from cores being modified into more formalised tools.
3) A lower percentage of retouched/utilised blanks, indicating the lesser importance of using/manufacturing of unmodified blanks to be utilised in tasks.

<u>A Note on the Total Lithic Assemblage to Retouched Tool Ratio</u>

As there is an uneven reporting of chips and waste flakes in excavation publications and reports (which is especially more pronounced in older excavations) the total lithic artefacts for this ratio will exclude chips and waste materials from the total. This effectively gives a combined total of the blanks, tools, and cores. As tools are a major component of this sum, and cores usually having low numbers and having little influence on the total lithic assemblage, this ratio is nearly identical to the blank to tool ratio (which includes utilised and retouched blanks in the tool total). Hence, the total lithic assemblage to retouched tool ratio will not be included. Instead only the blank to tool ratio will be considered as a possible measure of expediency in this study.

Tool Expediency

The ratios are expressed in decimal form, while the numbers of utilised and retouched blanks (URB) are expressed as a percentage. The B/T and B/C ratios will be considered first, followed by the percentage of URT.

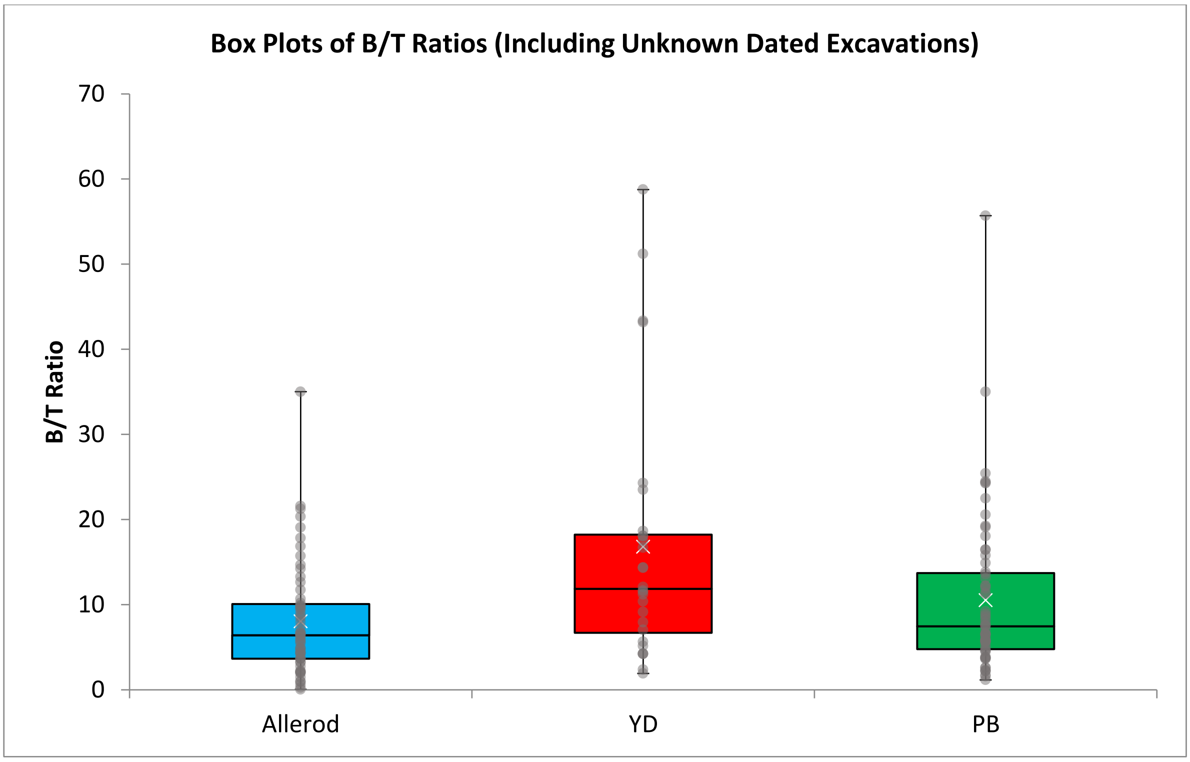
4.2a - Analysis of the Blank to Tool Ratio

Results

Table 4.8 and Fig 4.4 show the mean values for the B/T ratios for the whole dataset and each of the climatic phases and their transitions. The B/T ratio has been shown in Chapter 3 to be influenced by the date of excavation and so only assemblages excavated post-1960 have been included in this analysis. A further decision was made to include two sets of data, one with only assemblages with known excavation dates, and one which includes assemblages with unknown excavation dates. This action was taken in order to increase the sample size, while providing a more cautionary dataset for comparison. As it can be seen, there is little difference in the mean values for the whole dataset, the Allerød, the YD, and the PB between the two sets of data, but there is a notable difference in the Allerød/YD transition. However, as the transitional assemblages cannot be assigned to a definitive period, this data will be excluded from analysis but included in tables and diagrams. Thus, when reporting statistical data, the data from the larger dataset (including sites with unknown excavation dates) will be quoted in the text.

	μ (Including Unknown Excavation Dates)	**n**	**σ**	**σ^2**	**μ (Excluding Unknown Excavation Dates)**	**n**	**σ**	**σ^2**
Whole Dataset	13.289	195	18.141	329.091	13.842	175	18.952	359.174
Allerød	8.179	58	6.555	42.967	8.584	45	6.661	44.372
Allerød/YD	24.427	17	47.269	2234.374	30.095	13	53.104	2820.083
YD	16.814	28	14.922	222.680	16.814	28	14.922	222.680
YD/PB	19.517	29	17.677	312.492	20.039	26	18.530	343.373
PB	10.554	63	9.259	85.728	10.532	62	9.333	87.101

(Table 4.8: Mean B/T ratio for the whole dataset and each climatic phase including and excluding sites with unknown excavation dates)



(Fig 4.4: Box plots of the B/T ratio data presented in table 4.8, showing the mean (x), and including data point distribution for the assemblages from unknown excavation dates)

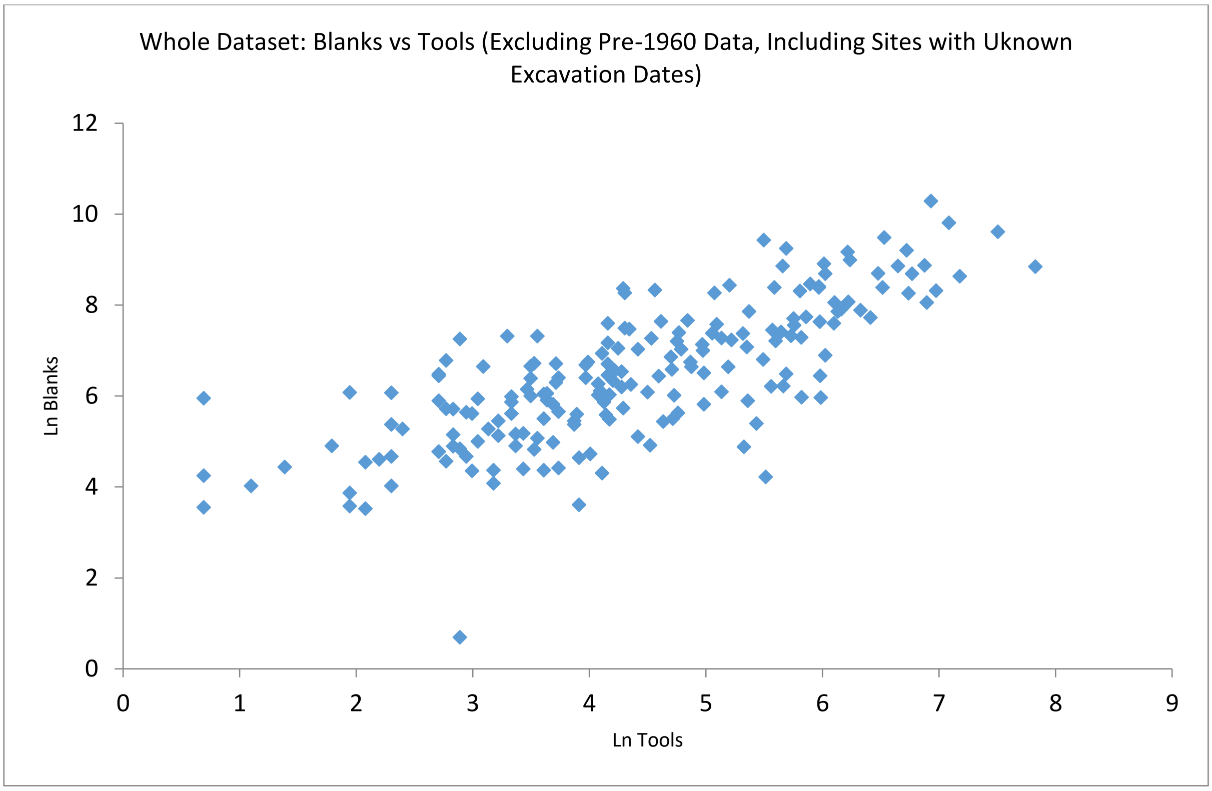
Analysis

It can be seen there is a significant relationship between the B/T ratios (Kruskal-Wallis rank sum test: (H(2) = 8.092, df = 2, p-value = 0.018) with an increase in the B/T ratio from the Allerød into the YD with a (p=0.002) (see statistics presented in A3.7 and A3.8 in Appendix 3). This indicates the mean values of B/T ratios in the YD sample are much higher than that of the Allerød, suggesting there is a significant increase in production of unmodified blanks during the YD, and may indicate a more expedient manufacturing strategy was being employed during this period. This then returns to a lesser value into the PB, which is also significant (p=0.042), suggesting there was a return to a more formalised manufacturing strategy, with less focus on the production of unmodified blanks during the PB. The mean values between the Allerød and PB show no significant difference, which one might expect from two interstadial phases with warmer conditions. This indicates there was a significant change to a greater level of logistical mobility during the YD compared with the Allerød and PD. There is also a distinctly greater variance in the YD sample, which indicates there was a greater variation in the B/T ratio between sites. This supports that a more logistical strategy was employed during this period, and as there is a significant change into and out of the YD but no significant change from the Allerød to the PB, strongly suggesting this change in the B/T ratio may be climate driven.

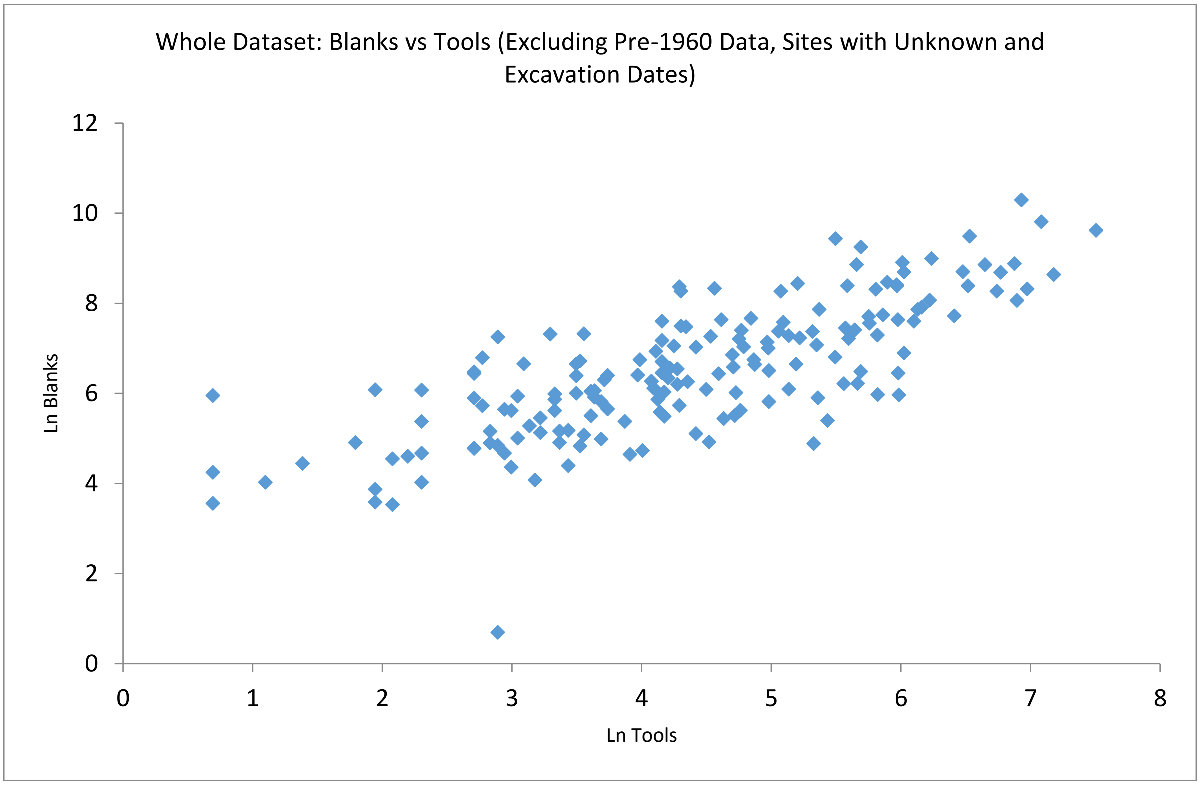
Graphical Comparisons of Blanks against Tools

Scatter plots were also produced in order to ascertain if there are any notable outliers and groupings, which may further show changes in mobility strategies. Outliers may highlight potentially unique site types, while groupings may highlight sites used for different functions, such as, special task camps and base camps.

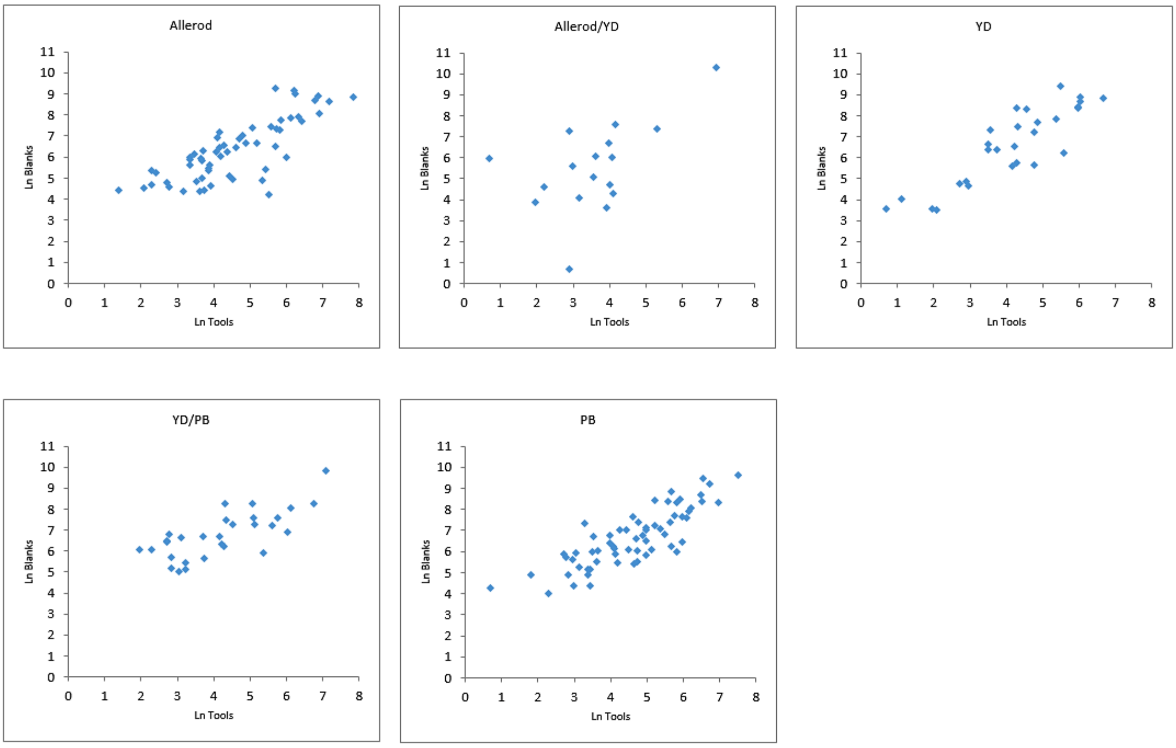
There is a clear positive correlation within the whole dataset (Fig 4.5 and 4.6) and within each climate phase and their transitions (Fig 4.7 and 4.8) which strongly suggest, as the number of blanks increase at a site, the number of tools also increase. This is expected as there is a logical link between the larger assemblages containing greater numbers of tools. There are two distinct outliers within the dataset, one is the site of Zolder, Site 1, dating to the Allerød/YD transition, which appears to be from a relatively intact sequence which was systematically excavated. This would imply this site is a real anomaly and may represent a special site type with a particularly high number of tools. However, as the Allerød/YD transitional sites are only included for interest, they are not subjected to analysis and does not factor in the comparisons of the climatic phases.



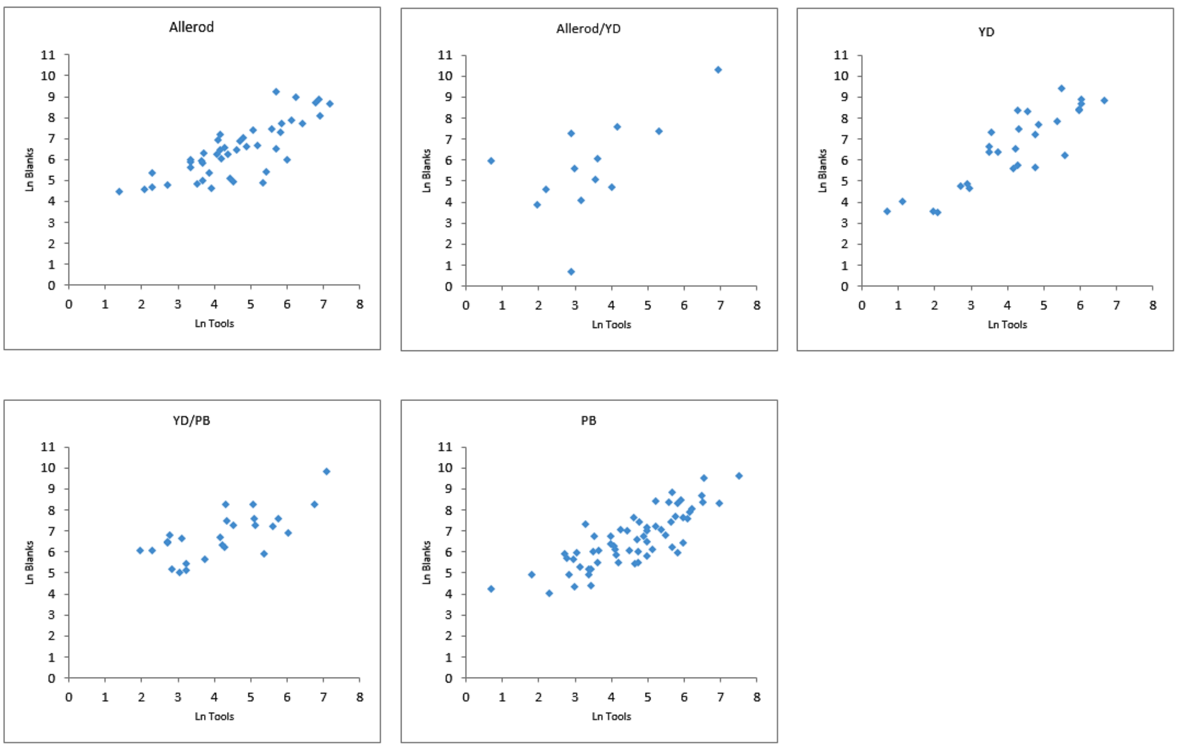
(Fig 4.5: Numbers of blanks to tools in the whole dataset, excluding pre-1960 data and including sites with unknown excavation dates)



(Fig 4.6: Numbers of blanks to tools in the whole dataset, excluding pre-1960 data and sites with unknown excavation dates)

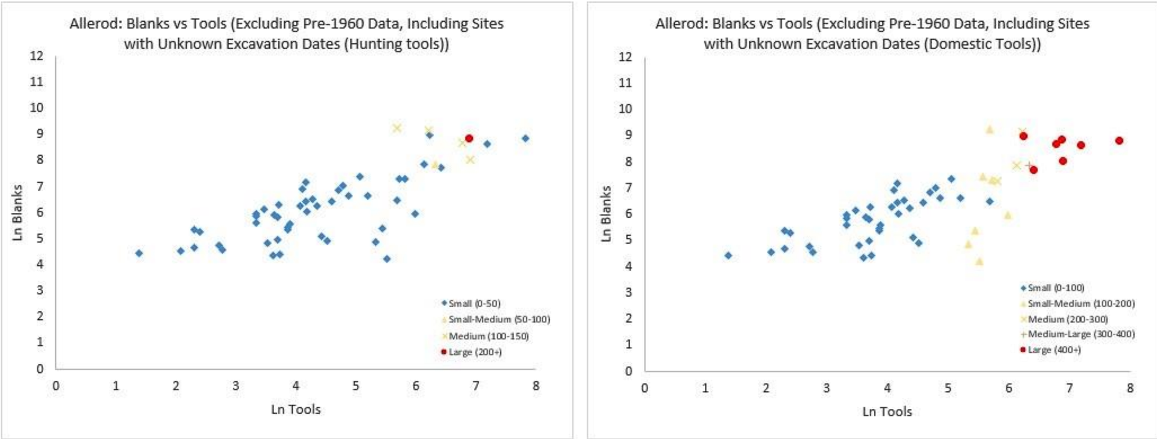


(Fig 4.7: The number of blanks against tools from each climatic phase of this study excluding pre-1960 data and zero points, but including sites with unknown excavation dates)

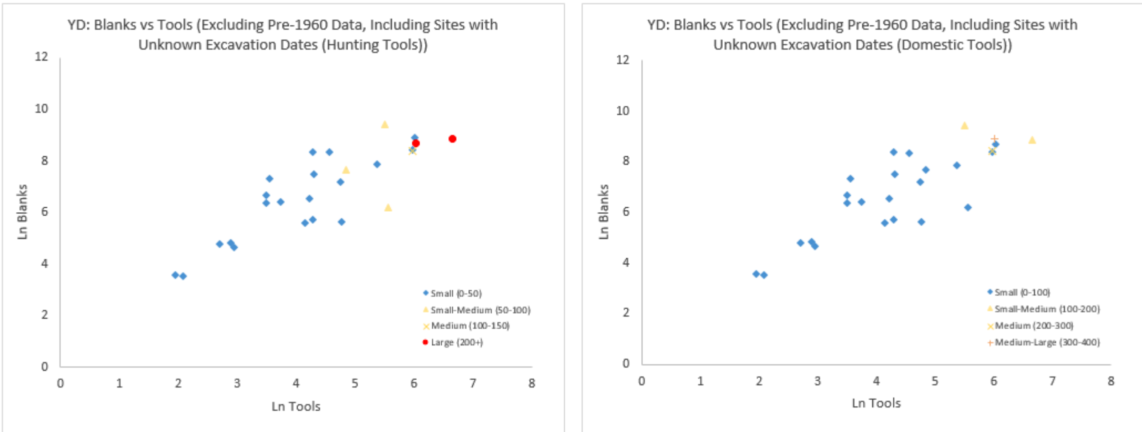


(Fig 4.8: The number of blanks against tools from each climatic phase of this study excluding pre-1960 data and zero points, and sites with unknown excavation dates)

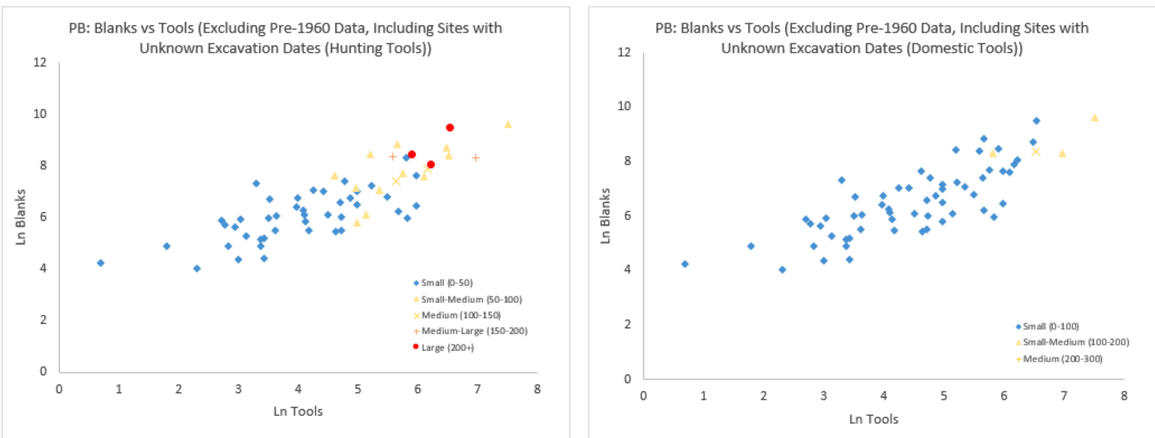
Numbers of Hunting and Domestic Tools



(Fig 4.9: The numbers of hunting tools and domestic tools in each assemblage in the Allerød sample)



(Fig 4.10: The numbers of hunting tools and domestic tools in each assemblage in the YD sample)



(Fig 4.11: The numbers of hunting tools and domestic tools in each assemblage in the PB sample)

It can be seen from Figs 4.9 to 4.11 the assemblages with larger numbers of blanks and tools contain the largest numbers of hunting and domestic tools, which one would expect. The Allerød appears to have a higher proportion of domestic tool dominated sites when compared with the YD and PB which both appear to have a larger proportion of sites with smaller domestic tool components and larger hunting tool components. This might suggest hunting becomes more important during the YD and PB, and suggests a potential shift to logistical mobility during these phases.

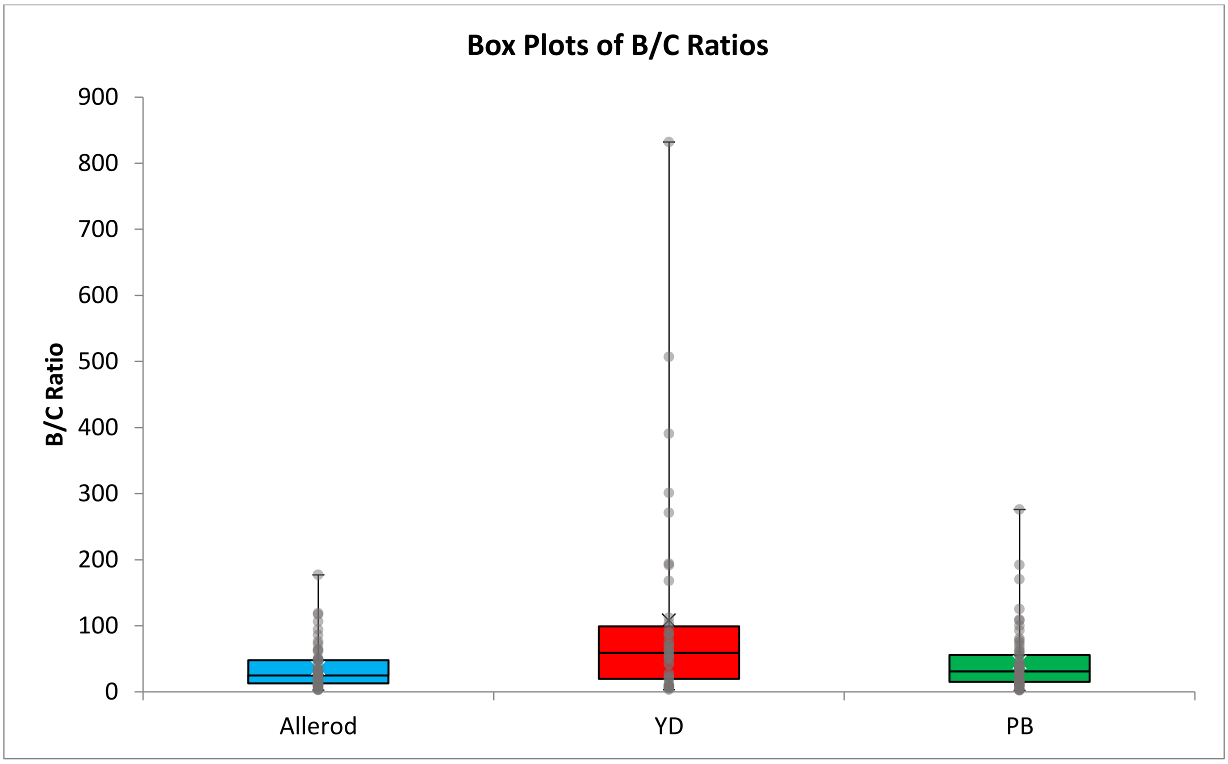
4.2b - Analysis of the Blank to Core Ratio

Results

The mean B/T ratio values show a distinct and significant increase during the YD, which suggests a potentially higher level of expediency seemingly related to the changing climate. Hence, it would be expected the B/C ratio would display a similar trend if this is true. Table 4.9 and Fig 4.12 show the mean values for the blank to core ratios for the whole dataset and each of the climatic phases and their transitions. Statistical analyses are presented in A3.9 in Appendix 3.

	μ	**n**	**σ**	**σ^2**
Whole Dataset	57.437	201	87.006	7570.052
Allerød	36.288	54	35.321	1247.579
Allerød/YD	56.716	15	52.378	2743.416
YD	107.821	40	160.556	25778.171
YD/PB	54.806	30	64.846	4204.986
PB	44.799	62	48.985	2399.568

(Table 4.9: Mean B/C ratio for the whole dataset and each climatic phase)



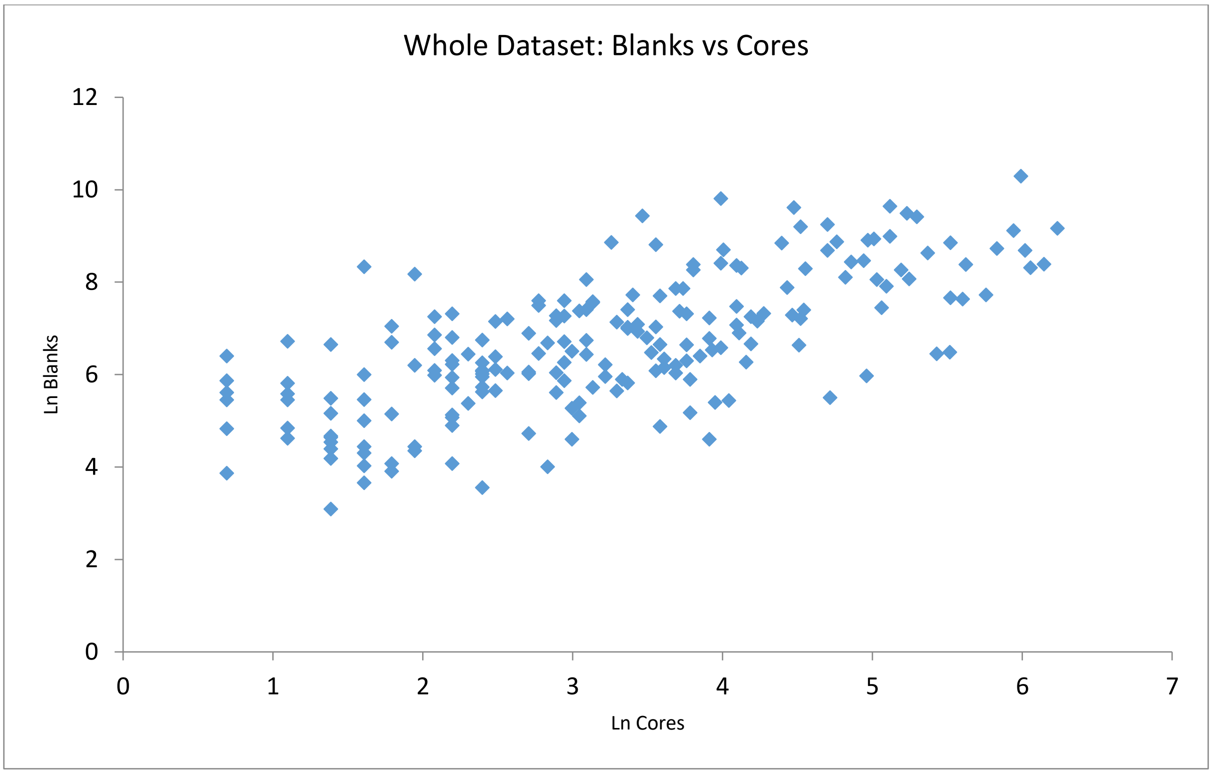
(Fig 4.12: Box plots of the B/C ratio data presented in Table 4.9, showing the mean (x), and including data point distribution)

<u>Analysis</u>

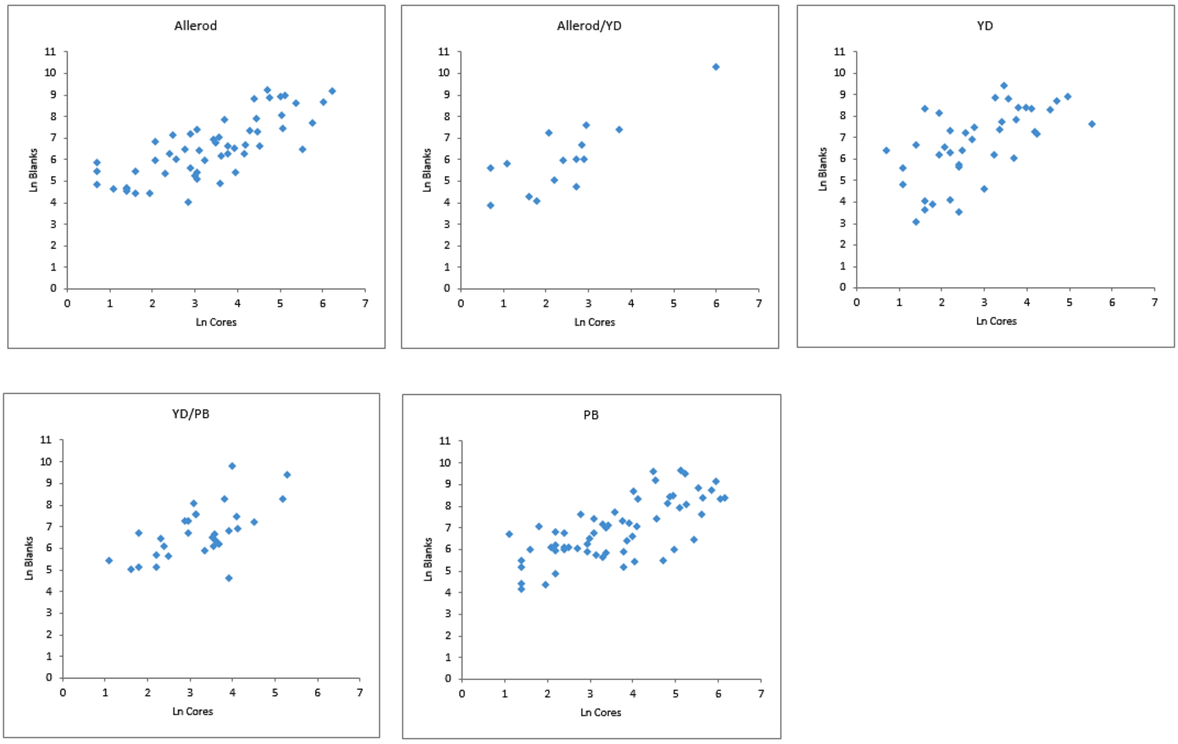
There was a significant relationship found between the periods (Kruskal-Wallis rank sum test: (H(2) = 8.231, df = 2, p-value = 0.016). It can be seen there is a large, significant, difference between the mean values of the YD and the Allerød (p=0.008), and the PB (p=0.024). This value is much higher than that of the Allerød and over the PB. The Allerød and PB, meanwhile, have comparable mean values with no statistical significance, suggesting there is a significant change in the numbers of blanks per core during the YD Stadial and not between the Allerød and PB interstadials. This might indicate a more wasteful, expedient, manufacturing strategy during the YD, where there was less importance on manufacturing formal tools from blanks. In contrast, during the Allerød and PB, there are far less blanks per core, suggesting there was more of an emphasis on manufacturing blanks into formal tools. This indicates there was a significantly greater level of logistical mobility during the YD compared with the Allerød and PB. Again, there is a distinctly higher variance during the YD, which again strongly supports that a logistical strategy was employed during this period. Once more, this is a potentially important result as there is a significant change into and out of the YD but no change from the Allerød to the PB, suggesting the B/C ratio may also be climate driven.

Graphical Comparisons of Blanks against Cores

When comparing the numbers of blanks and cores graphically, it can be seen, for the whole dataset (Fig 4.13), there is again a positive correlation similar to that seen in the B/T dataset. This suggests the numbers of cores generally increase as the number of blanks increase. This is an expected trend, as logically one would expect a greater number of blanks would be struck from a greater number of cores. When observing the individual climatic phases (Fig 4.14), it can be seen this positive trend is present in the Allerød, YD, and PB climatic phases, along with transitional data. There are no distinct outliers within the dataset, although the large site of Stoksbjerg Bro is clearly in the Allerød/YD transitional stage.

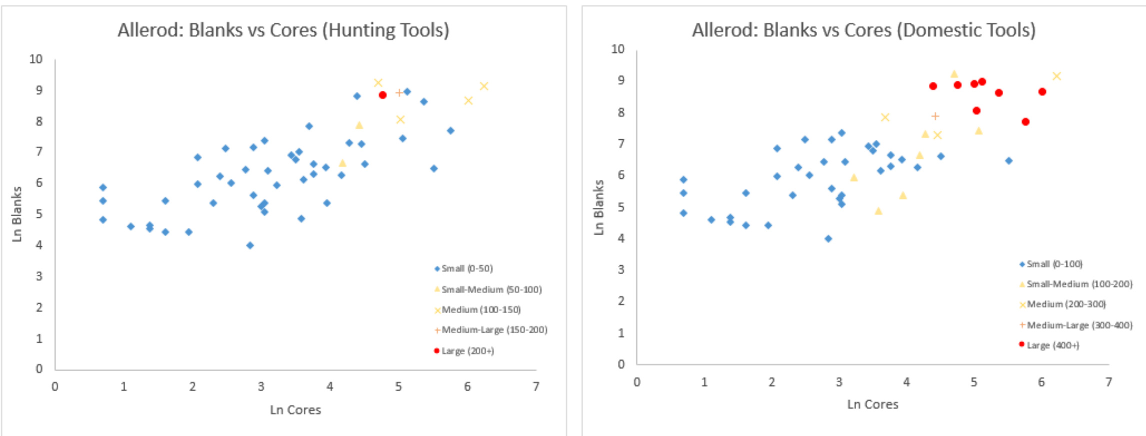


(Fig 4.13: Blanks against cores for the entire dataset)

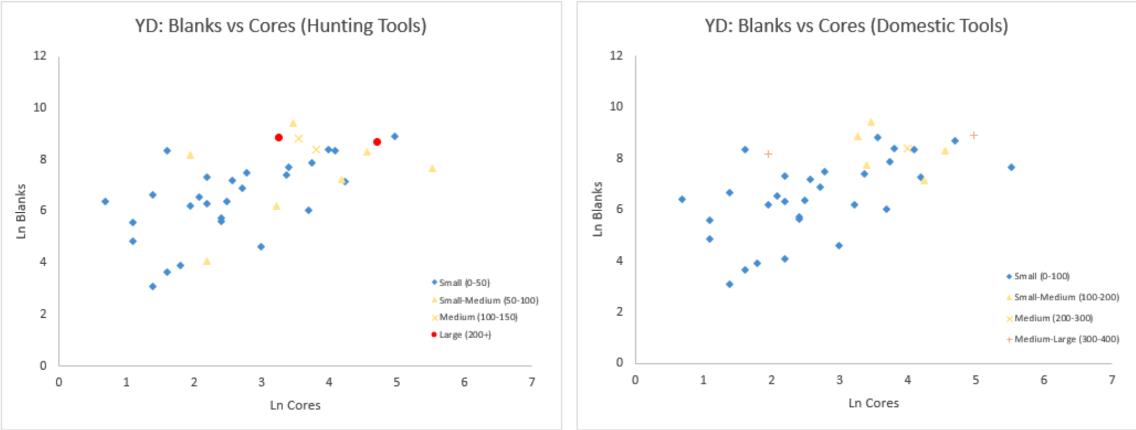


(Fig 4.14: Blanks against cores for each climatic period and transitional phase)

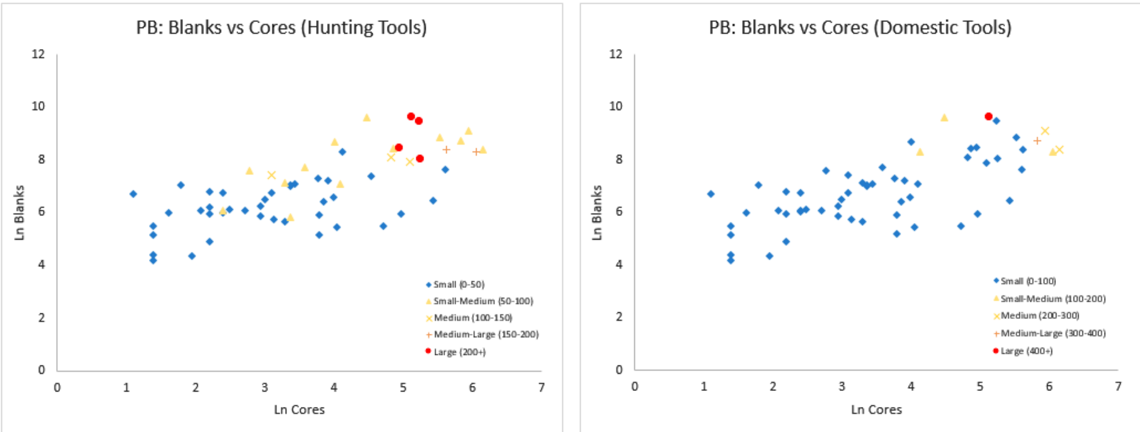
Numbers of Hunting and Domestic Tools



(Fig 4.15: The numbers of hunting tools and domestic tools in each assemblage in the Allerød sample)



(Fig 4.16: The numbers of hunting tools and domestic tools in each assemblage in the YD sample)



(Fig 4.17: The numbers of hunting tools and domestic tools in each assemblage in the PB sample)

It can be seen from Figs 4.15 to 4.17 that again there is a correlation, with the assemblages with the highest number of blanks and cores having the largest numbers of hunting and domestic tools. Again, it is shown there is a much higher proportion of assemblages with a larger domestic tool component during the Allerød than when compared with the YD and PB. This would be expected as once again blanks are one of the variables.

<u>4.2c - Analysis of the Percentage of Retouched and Utilised Blanks</u>

The above B/T and B/C ratio analyses strongly suggest a much higher, and statistically significant, increase in expediency during the YD. With this being the case, it would be expected the YD would also have a significantly higher percentage of URB's representing the more intensive use of unmodified blanks. It was decided two sets of analyses should be carried out (one for the percentage in the total assemblage and one for the percentage in the tool assemblage) in order to see if there are notable differences in the percentage composition.

<u>In Total Assemblage</u>

<u>Results</u>

Table 4.10 shows the mean values for the percentage of URB in the total assemblage for the whole dataset and each of the climatic phases and their transitions, with statistics presented in A3.10 in Appendix 3.

	μ	**n**	**σ**	**σ^2**
Whole Dataset	2.939	180	3.794	14.393
Allerød	3.165	52	3.862	14.915
Allerød/YD	2.203	13	3.265	10.659
YD	1.551	32	1.371	1.879
YD/PB	1.193	23	1.430	2.046
PB	3.809	60	4.449	19.792

(Table 4.10: Comparison of the weighted mean percentages of utilised and retouched blanks in the total assemblage of each climatic phase and their transitions)

<u>Analysis</u>

There was found to be a significant relationship between the periods (Kruskal-Wallis rank sum test: ($H(2) = 6.745$, df = 2, p-value = 0.034), and when observing the mean percentage of retouched and utilised blanks in the total assemblage, one can see the YD has a significantly lower mean value than the Allerød ($p=0.013$) and PB ($p=0.031$), while there is no significant difference between the means of the Allerød and PB interstadials. This strongly suggests there is a significant decrease in the numbers of URB in the total assemblage during the YD and indicates there is an increase in the level of mobility during the YD, and a lower level of mobility in the Allerød and PB. The distinctly lower variance of the YD further supports this, as one would expect little variation from site to site in a residential strategy, while it would be expected there would be a large variation between base camps (with a higher number of retouched blanks) and special task camps (with a lower number of retouched blanks and a higher number of formalised tools) in a logistical system. This is at odds with the results from the B/T and B/C ratios and may call into question the suitability of one or both of these analyses. Despite this, the observed change would also appear to be related to climate change with the Allerød and PB showing no significant difference in the percentage of URB's.

In Tool Assemblage

Results

Table 4.11 shows the mean values for the percentage of URB in the tool assemblage for the whole dataset and each of the climatic phases and their transitions, with the statistical analyses presented in A3.11 in Appendix 3.

	μ	n	σ	σ^2
Whole Dataset	23.964	193	18.479	341.484
Allerød	22.791	56	16.312	266.082
Allerød/YD	9.438	16	8.138	66.233
YD	18.267	32	12.414	154.098
YD/PB	15.934	24	8.470	71.738
PB	33.882	65	20.340	413.721

(Table 4.11: Comparison of the weighted mean percentages of utilised and retouched blanks in the tool assemblage of each climatic phase and their transitions)

Analysis

In this set of data only a near statistical relationship was found between periods (Kruskal-Wallis rank sum test: ($H(2) = 5.363$, df = 2, p-value = 0.068). When observing the mean percentage of URB within the tool assemblage, one can see there is only a significant difference in mean values from the YD and PB ($p= 0.019$). There is a relatively subtle increase in the number of URB's in the PB, suggesting there was a small shift to a lower level of mobility during the PB from the YD. However, there is no observable significant difference in the mean values from the Allerød and YD and the Allerød and PB. However, the finding that there were no significant differences between the Allerød and YD might indicate the change detected from the YD to the PB is not climate related. There is again a notably lower variance in the YD sample, but not to the same degree as in the total assemblage.

Summary of the Percentage of Utilised and Retouched Blanks

Overall, the evidence from this set of analyses seems to indicate there was a decrease in the percentages of URB's during the YD, which can be interpreted as an increase in more residentially mobile behaviour, and is at odds with the results from the B/T and B/C ratios. However, it is likely the reporting of URB's is variable, with the majority of publications quoting only retouched blanks, if at all. It is also highly likely utilised blanks have gone largely unreported or have at least been under reported, which is unsurprising considering the difficulties in recognising use-wear damage on blanks. With this in mind, it is considered this result might be an anomaly caused by this potential flaw in analysis, but will not be discarded as it is felt to do so might be a biased elimination of unexpected results.

4.2d - Summary of Expediency Analysis

It can be seen there appears to be a significant increase in both the B/T and B/C ratios during the YD compared with the Allerød and PB, which suggests there was a distinct increase in expedient tool manufacture by YD populations, which is no doubt related to the deterioration in climatic conditions during this period, as there appears to be no significant difference in either ratio between the Allerød and PB. This behaviour is associated with less mobile populations within a logistically mobile system. This result would suggest the percentage of URB's would also be significantly higher during the YD, representing an increase in unmodified blanks being utilised as tools. However, this appears not to be the case, as there are significantly lower percentages of URB's during the YD. There are two possibilities to explain this outcome. Firstly, the BT and B/C ratios are not suitable to determine levels of expediency and thus wrongly suggest here a more expedient strategy was employed when in fact there was not; or secondly, the percentage of URB's are not suitable to determine levels of expediency. The latter seems unlikely as an expedient strategy should have a higher percentage of URB's. However, there is a significant flaw in the URB data. This tool type is often difficult to recognise within an assemblage, especially in the case of utilised blanks, which are determined by scratches on the surface of blanks. Also, the reporting of URB's are highly variable, with very few excavations devoting a lot of attention to finding and identifying these tool types, while many recording them if they happen to be recognised and collected, and some simply not collecting and recording them at all. This is particularly pronounced with utilised blanks, which are rarely collected and reported due to the difficulty in recognising manmade scratches from post-deposition scratches. Due to this likely flaw with the URB data, it is concluded from this set of analyses, populations during the YD practised a distinctly higher level of expedient tool manufacture, indicating a shift to a more logistical mobility strategy, most likely in response to the climatic deterioration during this period.

A note on Maintenance and Analysis of Percentage of Chips and Small Debris

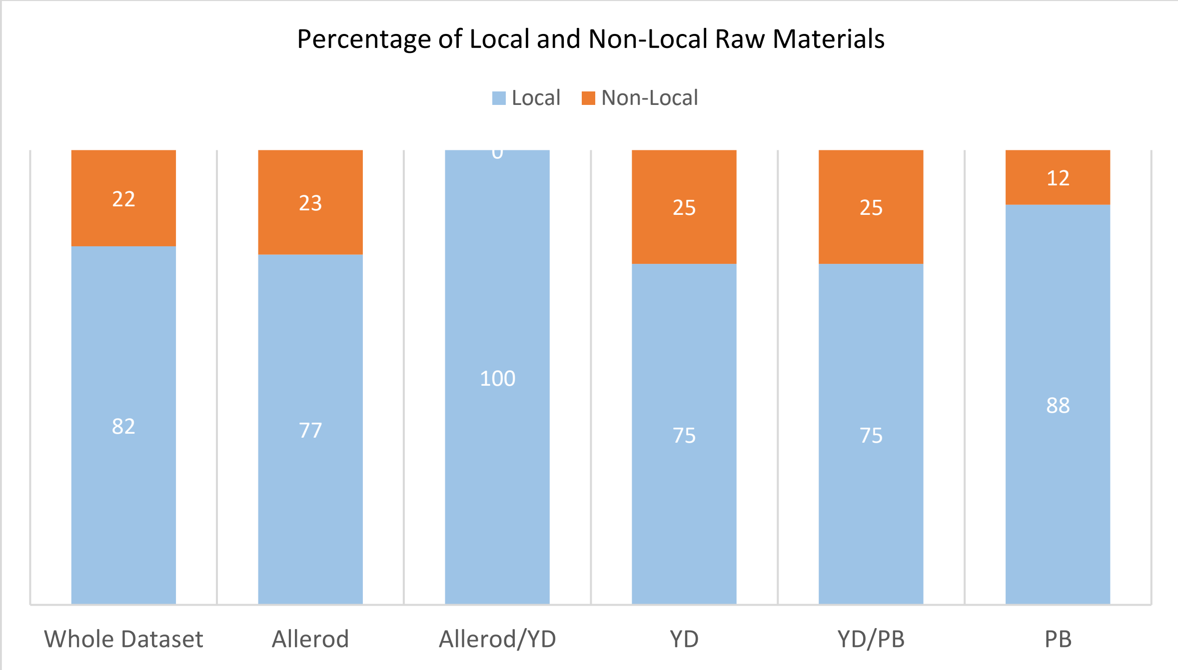
Chips have been proved to be unreliably reported and have been excluded from this analysis, as they are thought to be unable to provide sufficiently reliable results.

4.2e - Raw Material Procurement Analysis

The evidence from the diversity and expediency analyses suggests there was an increase in specialisation and expediency during the YD that could be argued to be linked to climate change. If these indications are correct, then one would expect the provenance of raw materials would be from more local sources during the YD, compared with that of the Allerød and PB, reflecting a decreased level of mobility expected in a more logistical strategy.

Analysis

Detailed information on raw material procurement was not reliably reported in many of the published reports. Consequently, to maximise the sample size, a simple classification of “predominately local” and “predominately non-local” was applied to the data, as this was the most commonly reported information. Importantly, it should be noted this classification is extremely subjective to each publication and its research history/culture in the country of origin along with the geology of the region a site is located. Fig 4.18 shows the proportions of local and non-local raw materials from each of the climatic phases and their transitions, while Table 4.12 presents the percentages of sites with predominately local and predominantly non-local raw materials.



(Fig 4.18: The numbers of assemblages with predominantly local or predominantly non-local raw materials for each climatic phase and their respective transitions)

	Percentage Local Raw Materials	**n**	**Percentage Non-Local Raw Materials**	**n**	**Total Percentage**	**n**
Whole Dataset	82	98	18	22	100	120
Allerød	77	30	23	9	100	39
Allerød/YD	100	7	0	0	100	7
YD	75	9	25	3	100	12
YD/PB	75	15	25	5	100	20
PB	88	37	12	5	100	42

(Table 4.12: Percentage of sites with predominately local and predominately non-local raw material sources)

Results

This dataset potentially indicates the PB has a distinctly higher percentage of sites with the predominant raw materials being procured locally (88%; n = 42) with the YD having the lowest percentage (75%; n = 12) and the Allerød having (77%; n = 39). The YD has a notably low sample size, which make direct comparisons difficult. However, the YD shows no distinct difference in the percentage of sites with predominately local raw materials from that of the Allerød. Therefore, one could potentially see a distinct increase in the procurement of raw materials from local sources during the PB, indicating a decrease in mobility, possibly related to an increase in logistical mobility strategies.

4.2f – Analysis of the Tool to Core Ratio

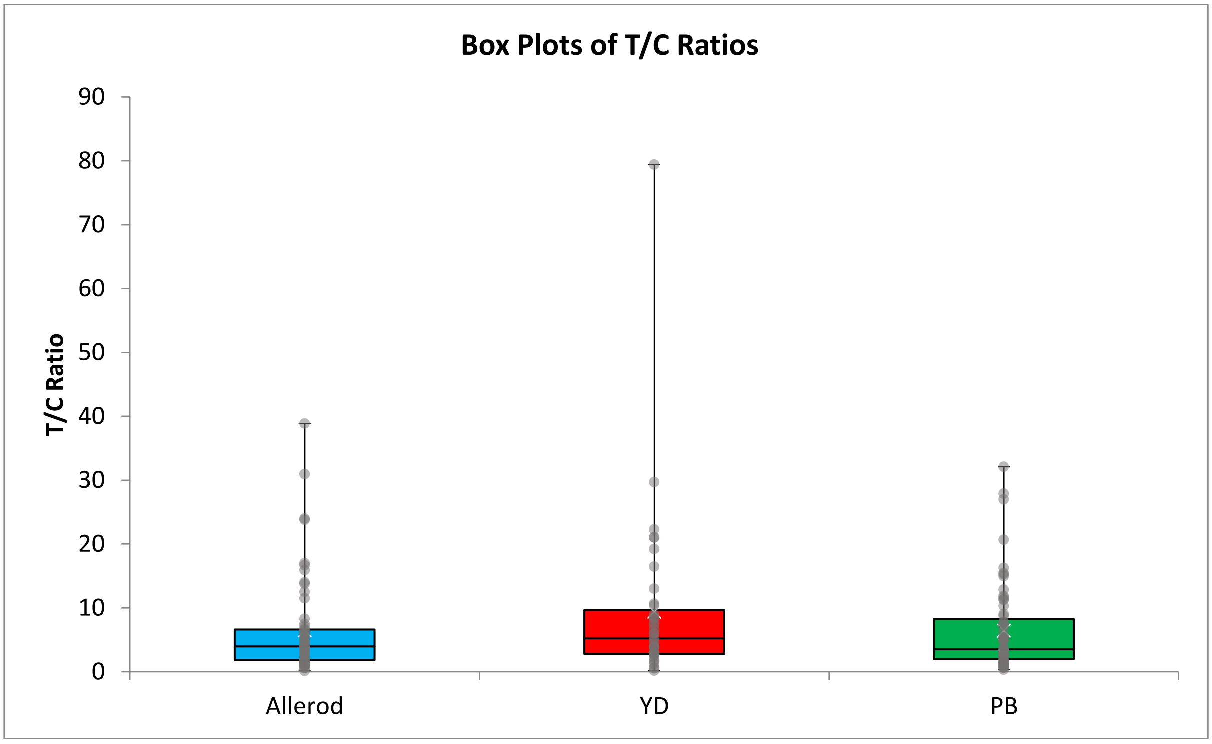
Analysis

The mean values of the T/C ratios are summarised in Table 4.13, and statistics presented in A3.12 in Appendix 3.

	μ	**n**	**σ**	**σ^2**
Whole Dataset	6.805	209	8.910	79.384
Allerød	6.494	58	7.714	59.505
Allerød/YD	4.523	18	4.542	20.633
YD	9.400	39	13.446	180.784
YD/PB	4.881	30	5.614	31.515
PB	6.426	63	6.892	47.498

(Table 4.13: Mean T/C ratio for the whole dataset and each climatic phase)

There is no statistically significant evidence of any changes in the T/C ratio from period to period (Kruskal-Wallis rank sum test: ($H(2) = 1.765$, $df = 2$, p-value = 0.414). However, the YD appears to have a distinctly higher mean value, which suggests a greater level of raw material economy, indicating a higher level of residential mobility was practised by populations during this period. However, the variance of this sample is also distinctly higher than the Allerød and PB, which indicates a greater level of variation in T/C ratios between sites, and thus a greater level of logistical mobility.

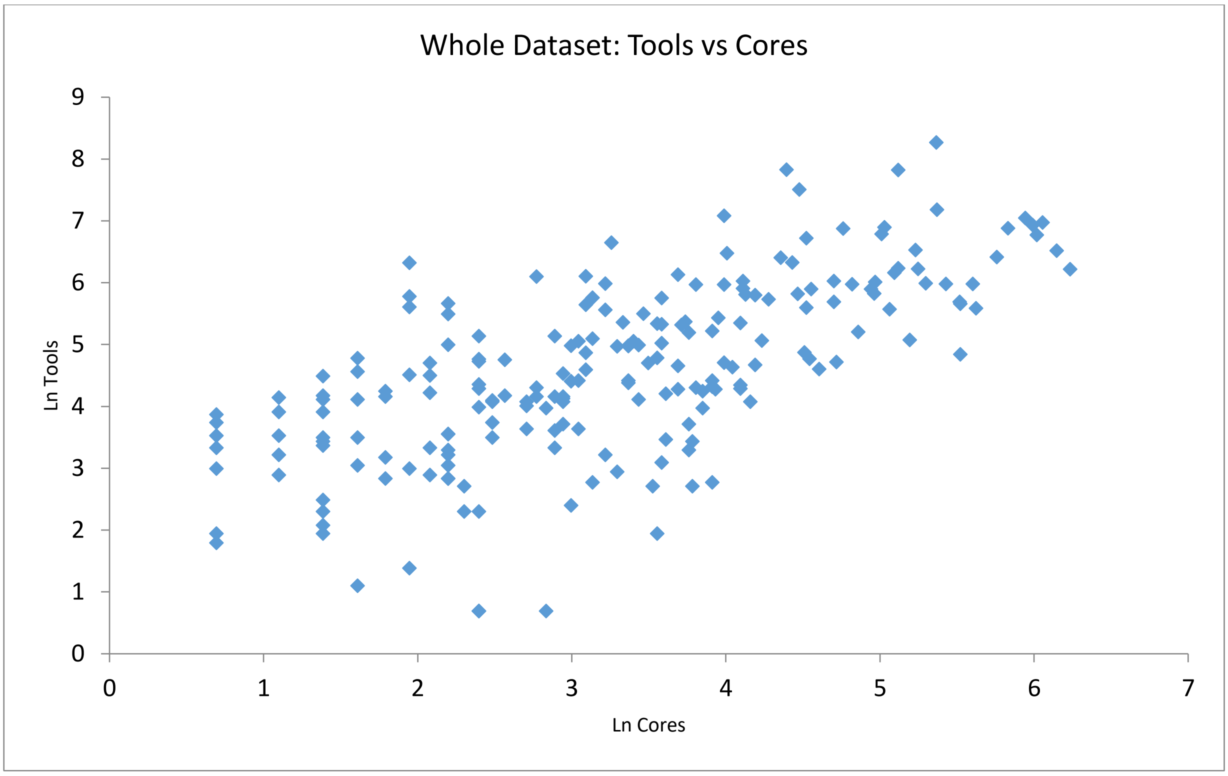


(Fig 4.19: Box plots of the T/C ratio data presented in table 4.13, showing the mean (x), and including data point distribution)

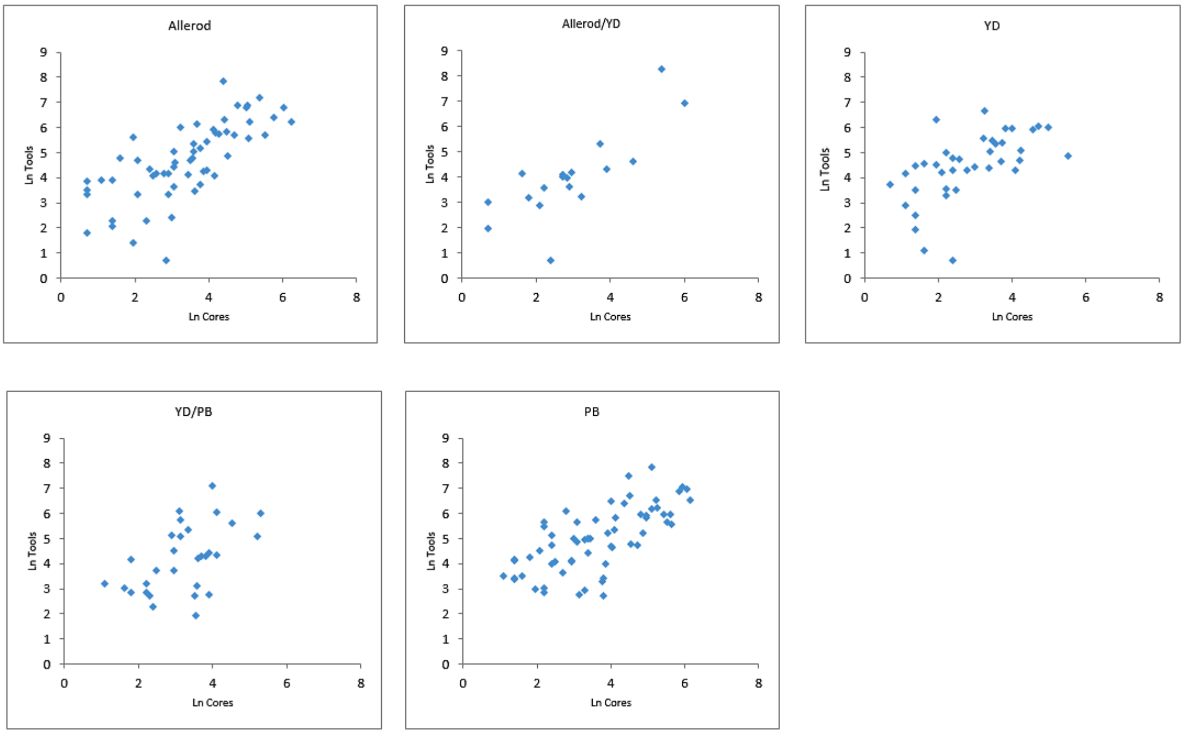
Graphical Comparisons of Blanks against Tools

Scatter plots were also produced in order to ascertain if there are any notable outliers and groupings, which may further show changes in mobility strategies. Outliers may highlight potentially unique site types, while groupings may highlight sites used for different functions, such as, special task camps and base camps.

There is a clear positive correlation within the whole dataset (Fig 4.20) and within each climate phase and their transitions (Fig 4.21) which strongly suggest, as the number of tools increase at a site, the number of cores also increase. This is expected as there is a logical link between the larger assemblages containing greater numbers of tools. However, there are six distinct outliers belonging to the sites of Éragny-sur-Epte and Olknitz dating to the Allerød; Hintersee, dating to the Allerød/YD transition; Hoogkerk and Notre-Dame-de-l'Isle dating to the YD; and Wawcott XII dating to the YD/PB. All of these sites appear to have been reliably excavated and thus appear to be actual anomalies that may represent unique behaviours/functions at these sites. Olknitz having a distinctly higher number of tools compared with cores and the remaining five having distinctly low numbers of tools compared with cores.

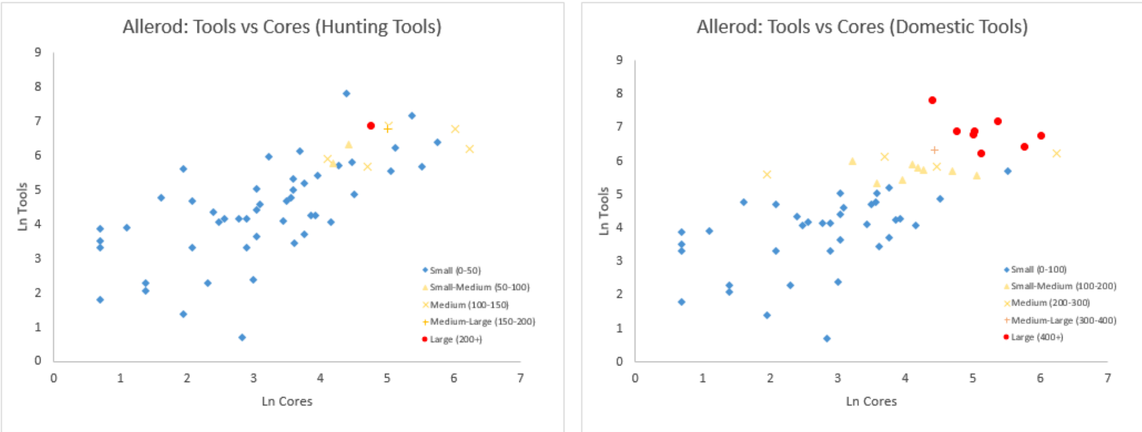


(Fig 4.20: Tools against cores for the whole dataset)

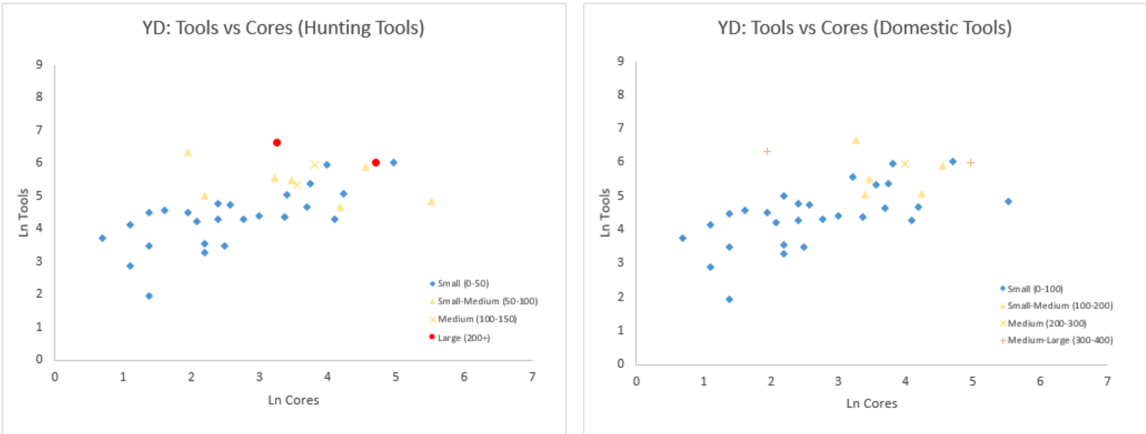


(Fig 4.21: Tools against cores for each climatic period and transitional phase)

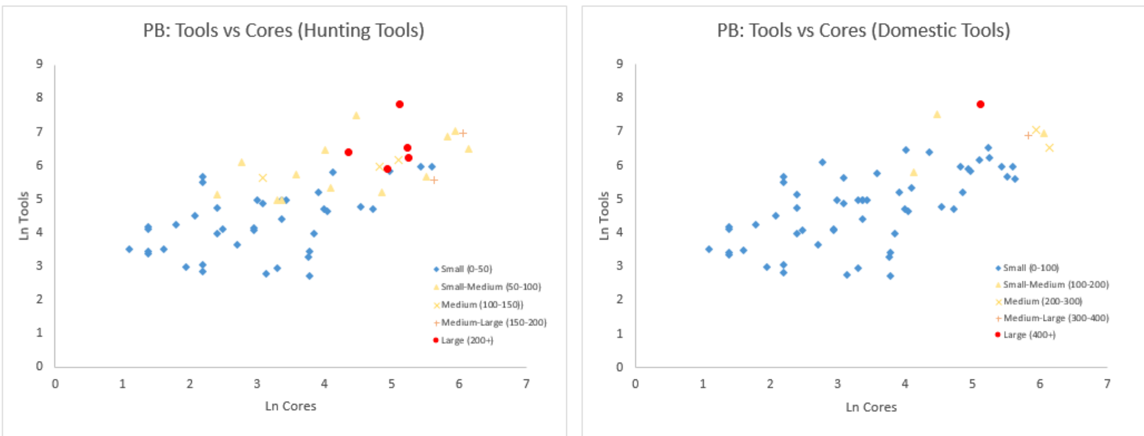
Numbers of Hunting and Domestic Tools



(Fig 4.22: The numbers of hunting tools and domestic tools in each assemblage in the Allerød sample)



(Fig 4.23: The numbers of hunting tools and domestic tools in each assemblage in the YD sample)



(Fig 4.24: The numbers of hunting tools and domestic tools in each assemblage in the PB sample)

Once again its can be seen the assemblages with the largest numbers of tools and cores have the highest numbers of hunting and domestic tools (Figs 4.22 to 4.24). Again, this shows the Allerød has a much higher proportion of assemblages with larger domestic tool components than hunting tool components when compared with the YD and PB. In fact, the PB appears to have a much higher proportion of assemblages with larger hunting tool components than domestic tool components than the YD. This suggests there was a continued rise in the importance of hunting from the Allerød through into the PB.

Results

The comparison of the mean values for the T/C ratio shows no significant differences between any of the climatic periods, suggesting that the T/C ratio does not change significantly from period to period. However, it is notable the YD ($n = 39$, $\mu = 9.400$, $\sigma = 13.446$) has a higher mean value compared with the Allerød ($n = 58$, $\mu = 6.494$, $\sigma = 7.714$) and PB ($n = 63$, $\mu = 6.426$, $\sigma = 6.892$). This might tentatively suggest there is a potential change to a higher T/C ratio during the YD, and might suggest a potentially greater level of economy with less cores utilised for a higher number of formal tools, but as no significant difference is found this interpretation must be viewed with caution.

One interesting result to note is the YD has a notably higher standard deviation and variance compared with the Allerød and PB possibly indicating a larger variance in site size, and possibly site types and functions.

4.3 - Site Type Analysis

In order to understand what impact the results of the analysis has in terms of mobility changes, we must determine the proportions of base camps, and special task camps in each climatic period. Tables 4.14 and 4.15 show the expected characteristics of base camps and special task camps in order to attempt to classify each site in this study as either a base camp or a special task camp (both hunting and non-hunting). This, of course, has an element of subjectivity and creates a binary system, where a site is either one or the other, and which may over simplify what is a complex set of factors. However, from the data available it is believed a good, general, idea of site type can be achieved and allows a possible valuable insight into hunter-gatherer mobility in different climatic phases.

Base Camps

	Incidence	**Archaeological Indicator**
Number of blanks	High	Percentage of blanks
Number of chips/maintenance products	High	Number of chips and/or flakes
Tool production products	High	Percentage of tool production products
Number of cores	High	Percentage of cores
Number of domestic tools	High	Scrapers, borers, burins etc.
Number of hunting tools	Low/Medium	Points, Microliths
Size of site	Large	Site size in m^2
Density of artefacts	Low	Density of artefacts in m^2, possibly total number of artefacts
Richness	High	NTAXA
Evenness	High	Simpson Index values

(Table 4.14: Characteristics of lithic assemblages in hunter-gatherer base camps seen both in logistically and residentially mobile populations)

Special Task Camps

	Incidence	Archaeological Indicator
Number of blanks	Low	Percentage of blanks
Number of chips/maintenance products	Low	Percentage of chips and/or flakes
Tool production products	Low	Percentage of tool production products
Number of cores	Low	Percentage of cores
Number of domestic tools	Low	Scrapers, borers, burins etc.
Number of hunting tools	High	Points, Microliths
Size of site	Small	Site size in m^2
Density of artefacts	High	Density of artefacts in m^2, possibly total number of artefacts
Richness	Low	NTAXA
Evenness	Low	Simpson Index values

(Table 4.15: Characteristics of lithic assemblages in hunter-gatherer special task camps seen only in logistically mobile populations)

Table 4.16 sets out a list of expectations as to what values are considered high, medium, and low for each indicator. These values were obtained from considering the average values for each indicator for the whole dataset. If an assemblage meets the criteria of over 4 out of 8 indicators of either a special task camp or a base camp site type, then it is classified as that site type.

However, an important modification was made to this set of expectations. It was decided special task camps were too highly dependent on hunting camps, ignoring potentially specialist sites for activities such as raw material collection or food processing, which would be expected to have little or no hunting tools present. Hence, if an assemblage shows most of the characteristics of a special task camp but with a high/medium number of domestic tools and a few hunting tools, the evenness values will be the deciding factor in its classification. If there is a dominance of domestic tools with a low level of evenness, this will be considered a non-hunting special task camp.

Indicator	High	Medium	Low
Blanks	>85%	75-85%	<75
Cores	>4%	3-4%	<3%
Hunting Tools	>30	15-30%	<15%
Domestic Tools	>75%	65-75%	<65%
Area	>100m^2	50-100m^2	<50m^2
Density	>20 per m^2	10-20 per m^2	<10 per m^2
Simpson Index Value	>6	3-6	<3

(Table 4.16: Table of expected values for high, medium, low levels of each indicator)

Table 4.17 shows the results when these expectations are applied to the database for the northwest European sample.

	No. Base Camps	% Base Camps	No. Special Task Camps	% Special Task Camps	n Total	% Total
Whole Dataset	90	47.12	101	52.88	191	100
Allerød	45	58.44	32	41.56	77	40.31
YD	13	28.89	32	71.11	45	23.56
PB	32	46.38	37	53.62	69	36.13

(Table 4.17: Number and percentage of base camps and special task camps recognised using the parameters set out in Tables 4.14 and 4.15 for the whole database and each climatic phase)

These results appear to show the YD has distinctly fewer numbers of base camps and a distinctly greater number of special task camps compared with the Allerød and PB. This suggests populations during the YD practised a higher level of logistical mobility with fewer, possibly longer occupied, base camps represented in this sample and a large number of logistical special task camps.

To further understand if these differences are significant, Table 4.18, sets out the expectations of expediency for base camps in a residential strategy, base camps in a logistical strategy, and special task camps (which for the purposes of this set of analysis are assumed to be only found in logistically mobile populations).

Characteristics of Lithic Assemblage	High Mobility	Archaeological Indicator	Low Mobility	Archaeological Indicator	Special Task Camps	Archaeological Indicator
Proportion of formal tools	High	Low B/T Ratio Low B/C Ratio	Low	High B/T Ratio Low B/C Ratio	High	Low B/T Ratio Low B/C Ratio
Proportion of formal tools showing facial thinning	High	High % of tools with facial thinning	Low	Low % of tools with facial thinning	?	?
T/C ratio	High	High T/C Ratio	Low	Low T/C Ratio	High	High T/C Ratio
Percentage of prepared platforms	High	High % of prepared platforms	Low	Low % of prepared platforms	High	High % of prepared platforms

(Table 4.18: Characteristics of expediency in high and low mobility hunter-gatherer populations and in special task camps)

If we accept, from the results in Table 4.17, populations during the Allerød and PB practised a more residentially mobile strategy, and populations during the YD practised a more logistically mobile strategy, then we would expect (from the expectations set out in Table 4.14) the Allerød and PB to have base camps with a lower B/T, and B/C ratio, and a higher T/C ratio than base camps during the YD. The next section will look at the differences between the Allerød and PB base and special task camps and the YD base and special task camps.

4.3a - Base Camps

If sites can be classified as base camps, then their compositions would be expected to change if mobility changes with the change in climate into the YD. Base camps in a logistical system should have a distinct range of values representing a more expedient strategy with larger base camps, which are occupied for longer periods and moved less frequently than with a more residential system. Table 4.19 shows the results of the comparisons of the mean B/T, B/C, and T/C ratios for the assemblages designated as base camps between the Allerød, YD, and PB, with the statistical analysis presented in A3.13-A3.15 in Appendix 3.

	Allerød Base Camps				YD Base Camps				PB Base Camps			
Indicator	n	μ	σ	σ^2	n	μ	σ	σ^2	n	μ	σ	σ^2
B/T Ratio	43	8.356	5.897	34.778	13	14.253	10.402	108.251	32	9.457	10.049	100.977
B/C Ratio	38	34.997	36.163	1307.758	13	93.991	83.567	6978.391	29	44.668	52.195	2724.358
T/C Ratio	40	6.123	6.692	5.727	13	6.967	5.468	29.901	29	6.340	6.008	36.001

(Table 4.19: Mean B/T, B/C, and T/C ratios for the assemblages classed as base camps for each climatic phase)

The results of the mean B/T and B/C values, potentially show there is a statistically significant difference between the YD, and the Allerød and PB. Both the B/T and B/C values are significantly higher than during the interstadial periods (p=0.014; p=0.001 and p=0.0008; p=0.008), suggesting base camps during the YD were much more expedient than during the Allerød and PB, which one would expect from the previous analyses in this study. However, there is no significant difference observed between the T/C values of any of the periods suggesting the relationship between tools and cores remain similar within base camps from different strategies.

4.3b - Special Task Camps

If these sites are classified as logistical camps, then their compositions would not be expected to be significantly different from each other between each climate phase, as one would expect a special task camp to retain similar characteristics, whatever the level of residential or logistical mobility is being practised. Tables 4.20 show the results of the comparisons of the mean B/T, B/C, and T/C ratios for the assemblages designated as special task camps between the Allerød, YD, and PB, with the statistical analyses presented in A3.16-A3.18 in Appendix 3.

	Allerød Special Task Camps				YD Special Task Camps				PB Special Task Camps			
Indicator	n	μ	σ	σ^2	n	μ	σ	σ^2	n	μ	σ	σ^2
B/T Ratio	29	7.303	8.052	64.832	30	14.463	14.737	217.180	36	10.463	7.910	62.582
B/C Ratio	19	53.036	41.378	1712.147	30	108.791	179.179	32105.140	35	48.468	51.243	2625.823
T/C Ratio	20	10.670	12.288	150.988	31	10.226	14.734	217.096	36	6.560	7.977	63.639

(Table 4.20: Mean B/T, B/C, and T/C ratios for the assemblages classed as special task camps for each climatic phase)

The results of the mean B/C and T/C values show there are no significant differences between any of the periods, supporting their characterisation as special task camps, although the YD appears to have a much higher B/C ratio, over double the size of the Allerød and PB. However, the results of the mean B/T ratios are inconclusive, with the values being significantly lower in the Allerød compared with the YD (p=0.02) and significantly lower in the Allerød compared with the PB (p=0.0005). This might suggest the B/T ratio is variable in special task camps in different mobility systems, or possibly cast doubt on the special task camp designations. If we assume the former, it might be considered likely that more expedient tool manufacturing strategies, usually associated with base camps in a logistical system, could have occurred during the YD, and perhaps have extended to the special task camps.

4.3c - Comparison of Base camps and Special Task Camps

Now we have shown there are some potentially significant differences in line with more residentially mobile base camps in the Allerød and PB, and more logistically mobile base camps during the YD, along with the general lack of significant differences between the designated special task camps between any of the periods, we need to prove if there are any significant differences between the values of the base camps and special task camps. The results are presented in Tables 4.21 to 4.23, with statistics presented in A3.19-A3.21 in Appendix 3.

Allerød

	Allerød Base Camps				Allerød Special Task Camps			
Indicator	n	μ	σ	σ^2	n	μ	σ	σ^2
B/T Ratio	43	8.356	5.897	34.778	29	7.303	8.052	64.832
B/C Ratio	38	34.997	36.163	1307.758	19	53.036	41.378	1712.147
T/C Ratio	40	6.123	6.692	5.727	20	10.670	12.288	150.988

(Table 4.21: Mean B/T, B/C, and T/C ratios for the assemblages classed as base camps and special task camps for the Allerød)

Younger Dryas

	YD Base Camps				YD Special Task Camps			
Indicator	n	μ	σ	σ^2	n	μ	σ	σ^2
B/T Ratio	13	14.253	10.402	108.251	30	14.463	14.737	217.180
B/C Ratio	13	93.991	83.567	6978.391	30	108.791	179.179	32105.140
T/C Ratio	13	6.967	5.468	29.901	31	10.226	14.734	217.096

(Table 4.22: Mean B/T, B/C, and T/C ratios for the assemblages classed as base camps and special task camps for the YD)

Preboreal

	PB Base Camps				PB Special Task Camps			
Indicator	n	μ	σ	σ^2	n	μ	σ	σ^2
B/T Ratio	32	9.457	10.049	100.977	36	10.463	7.910	62.582
B/C Ratio	29	44.668	52.195	2724.358	35	48.468	51.243	2625.823
T/C Ratio	29	6.340	6.008	36.001	36	6.560	7.977	63.639

(Table 4.23: Mean B/T, B/C, and T/C ratios for the assemblages classed as base camps and special task camps for the PB)

There is no statistical difference between the B/T, B/C, and T/C ratio values between the designated base camps and special task camps in any of the climatic periods. This is somewhat unexpected as one would expect a distinct difference representing the different functions and sizes of these sites. In terms of evenness, there appears to be no difference in low or high levels of evenness and the values of these indicators. This either suggests the characteristics of expediency (formal and expedient tool manufacture) expected in base camps is also imitated in special task camps. The fact there appears to be some potentially significant differences in the mean values of the B/T and B/C ratios between base camps from each period might go some way to support this. However, it is also likely these indicators are not sensitive enough to pick up changes in compositions of assemblages in different site types. However, one might logically suggest, in an expedient strategy, with a large number of unmodified blanks being utilised as tools at base camps, that special task camps would also have a greater number of blank-tools exported to them. Likewise, in a more formal strategy with a higher number of tools than blanks, one might expect there would be fewer blanks at base camps and as a result fewer blanks would be taken offsite to specialist camps.

One interesting result is the YD values for each indicator seem to have much higher standard deviations and variances, suggesting a large range of values from the mean than the Allerød and PB, which may hide a greater variation of site types and sizes during the YD.

4.3d - Summary of Site Type Analysis

Overall, if we accept the allocation of the site types, there were a notably lower number of base camps and a higher number of specialist task camps during the YD. This strongly suggests there was a distinctly more logistical strategy employed by populations during the YD and supports the generalised conclusions of the previous analyses.

This conclusion is further supported when comparing the B/T, and B/C values of the designated base camps, which show there are distinctly significantly higher values during the YD, reinforcing their allocation to a more logistical strategy. The comparison of special task camps is more complex, but the fact there is not uniform, significant difference between each period might suggest there is less difference between special task camps from period to period, which would be expected due to their function. However, what is surprising is there are no significant differences between base camps and special task camps in each of the periods. This might suggest the toolkit characteristics of a certain mobility strategy extend from the base camp to their special task camps. However, this could also show these indicators are not sensitive enough to observe differences between specific site types, and only suitable for observing generalised strategies.

4.4 - Conclusion

The results of the B/T, B/C values, richness, and evenness values, and to some degree the raw material analysis, all appear to generally point to a shift from more mobile populations in a more residential system during the Allerød to less mobile populations in a more logistical system during the YD, and reverting back to a more residential system during the PB. These results are further supported by the analysis of site types, in which there appear to be clearly less base camps and a greater number of special task camps during the YD, strongly pointing to a more logistical system during this period. However, these site type results should be viewed with caution as the designation of site types could be seen as highly subjective. Interestingly, many of the indicators point to a much more complex situation during the PB, although many of these indicators are flawed due to the limitations of the data that could be collected from the publications for this period. In most of the analyses, the PB is often distinctly different from the Allerød and is often the opposite of what would have been expected. It is the opinion here the highly variable climate of the PB brought about a very distinct set of characteristics which seem to be particular to this interstadial phase, possibly comprising a combination of the behaviours hinted at during the Allerød and the YD.

This chapter has analysed and described the results of the north-western European dataset. The following Chapter 5, will instead focus on the southern European comparative dataset in order to determine if the expectations predicted for north-western Europe differ from that of the south. One would expect, due to the relatively subdued climatic response to the YD in southern Europe, there should be distinct differences between the two sets of data, with less distinct shifts in behaviour from the Allerød, to the YD, and to the PB.

Chapter 5: Southern Comparative Data Analysis

The previous chapter provided an analysis of lithic assemblages of sites from north-western Europe to highlight the changes, if any, in composition that could be related to mobility change and thereby to climatic change.

If the indicators employed in Chapter 4 do indeed provide the necessary clarity to determine changes in mobility, then it would be expected there would be notable differences in the characteristics of assemblages from the south of Europe. In the south, the climatic changes associated with the YD would be less pronounced and hence any changes in mobility in response to these changes would also be expected to be less pronounced or different from those of their north-western counterparts. This chapter draws on the framework of Chapter 4 in order to determine if there are differences in lithic assemblage composition between the northwest and south of Europe.

This chapter will present the results of the analyses of the mobility indicators, set out in table 4.1 in Chapter 4, to compare and contrast the level of diversity and expediency within the tool assemblages from each climatic phase, the mean values of each variable were calculated for each period and then compared statistically firstly using Kruskal-Wallis test followed by post-hoc tests using the Mann-Whitney U test (MW-U) and Dunn's test with Bonferroni correction. Statistical analysis was carried out using R.

5.1 – Tool Diversity Indicators

5.1 a – Analysis of Richness (NTAXA)

Results

The results of the NTAXA analysis are presented in Table 5.1, and statistics presented in A3.22 in Appendix 3.

	μ	n	σ	$σ^2$
Whole Dataset	7.751	131	1.934	3.739
Allerød	7.179	45	1.796	3.224
YD	8.660	37	2.579	6.652
PB	8.084	39	1.494	2.233

(Table 5.1: Weighted mean richness (NTAXA) for the whole dataset and each climatic phase)

Analysis

It was found from Table 5.1 and A2.22, there is no statistically significant difference between the means of any of the three climate phases (Kruskal-Wallis rank sum test: ($H(2) = 0.696$, df = 2, p-value = 0.706), the values being fairly similar to each other. This suggests there was no discernible difference in the number of tool types between each period. However, there appears to be a notably larger value of richness during the YD (especially compared with the Allerød) which might indicate an increase in residentially mobile behaviour by populations during this period, but the variance of this sample is also notably higher than the Allerød and PB which alternatively suggests there was a greater variation of numbers of tool types during this period. One might expect this to be a characteristic of a more logistically mobile population.

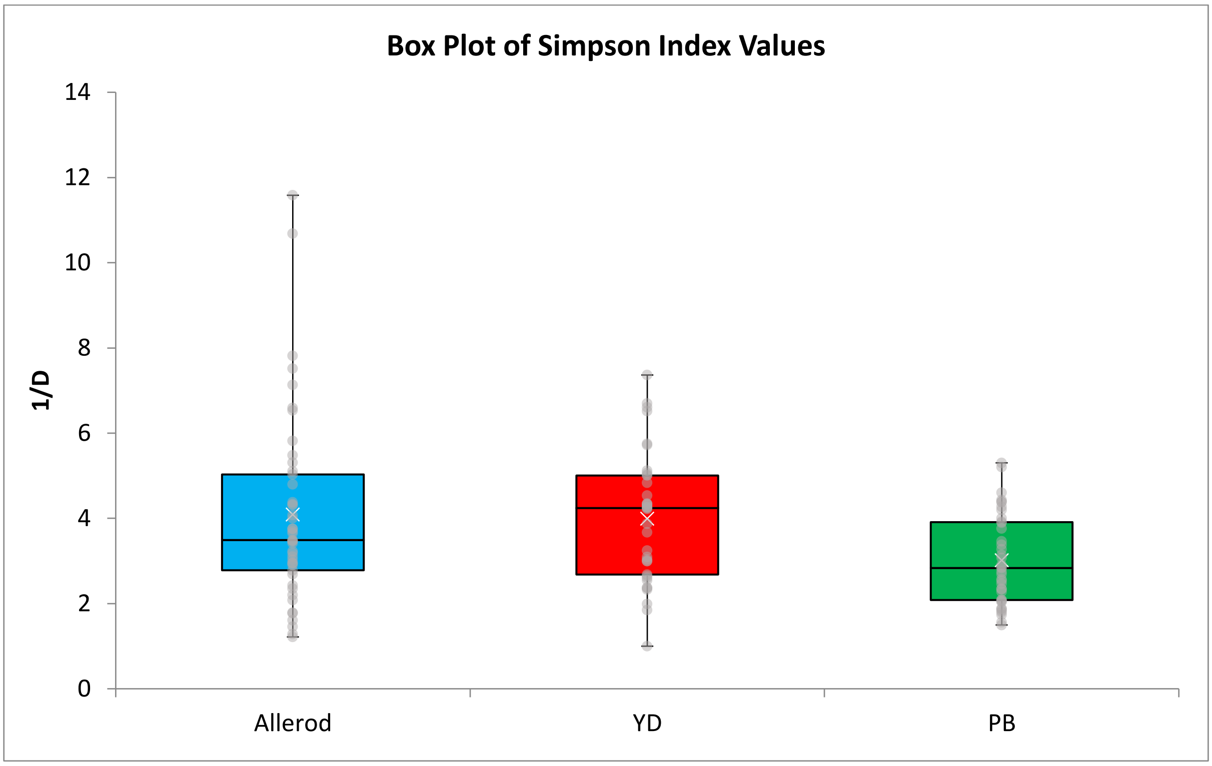
5.1b – Analysis of Evenness

Results

The results of the Simpson Index calculations are presented in Table 5.2 and Fig 5.1, and the statistical analyses presented in A3.23 in Appendix 3. The lowest possible value is 1, which would represent the total dominance of the assemblage by a single taxon. Therefore, again, the larger the value the greater the level of evenness of the assemblage.

	μ	n	σ	σ^2
Whole Dataset	3.704	131	1.714	2.936
Allerød	4.094	45	2.249	5.057
YD	3.997	37	1.506	2.269
PB	3.018	39	1.057	1.116

(Table 5.2: Mean Simpson Index values for the whole dataset and each climatic phase)



(Fig 5.1: Box plots of the Simpson Index data presented in Table 5.1, showing the mean (x), and including data point distribution)

<u>Analysis</u>

It can be seen there is a significant relationship between the periods (Kruskal-Wallis rank sum test: (H(2) = 9.000, df = 2, p-value = 0.011). However, no significant difference in the means between the Allerød and YD were found, with the values being very similar to each other. This suggests there was no change in the level of generalisation or specialisation through from the YD into the Allerød. There is a significant decrease in the mean Simpson Index values from the Allerød (p=0.025) and the YD (p=0.004) into the PB, indicating a distinct shift to a less even, more specialised mobility strategy during the PB when compared with the Late Palaeolithic dated assemblages. However, the Allerød displays a distinctly higher variance which might suggest a higher level of logistical mobility was employed during this period, while the PB has the lowest variance, suggesting there was little variation in evenness between sites, and thus potentially providing evidence of a more residential strategy.

5.1c – Analysis of Density

Results

Total Artefacts per m^2

The results of the total number of artefacts per m^2 are presented in Table 5.3, and the statistics presented in A3.24 in Appendix 3.

	μ	n	σ	$σ^2$
Whole Dataset	163.670	81	290.220	84227.817
Allerød	192.776	30	306.915	94196.831
YD	148.378	23	343.585	118050.490
PB	161.274	24	239.589	57402.872

(Table 5.3: Mean density per m^2 in the BCT assemblage for the whole dataset and each climatic phase)

Summary of Results

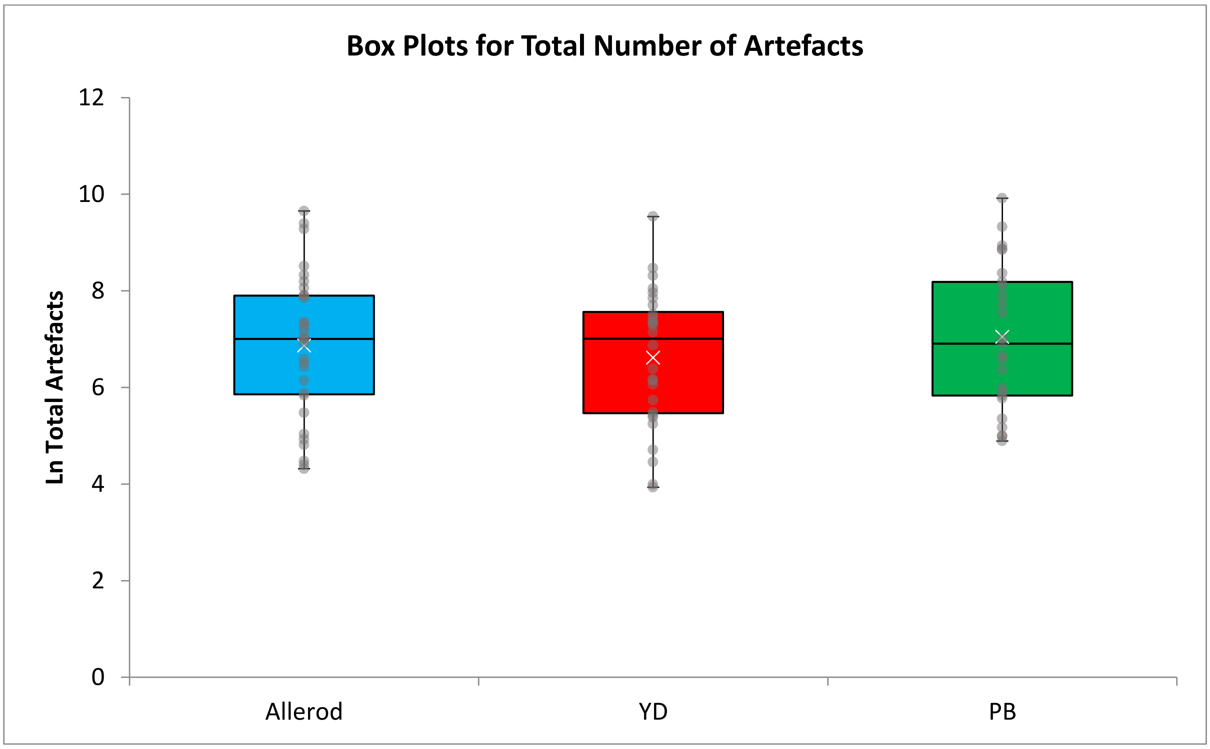
Overall, no significant difference is apparent between the mean densities per m^2 of artefacts and between any of the periods (Kruskal-Wallis rank sum test: (H(2) = 2.719, df = 2, p-value = 0.257). However, the YD appears to have a slightly smaller mean density which may indicate a small shift to a more residentially organised system, although the YD has a distinctly higher variance, which may indicate a higher level of logistical mobility. In this analysis, there is also a distinct, although not statistically significantly, higher mean density during the Allerød which may suggest populations during the Allerød practised a higher level of logistical mobility, supported by the higher variance.

Total Number of Artefacts

Table 5.4 and Fig 5.2 present the results of the total number of artefacts, with the statistical analyses presented in A3.25 in Appendix 3.

	μ	n	σ	σ^2
Whole Dataset	2300.211	90	3624.332	13135785.920
Allerød	2463.484	31	3716.148	13809756.260
YD	1746.000	28	2693.750	7256290.296
PB	3104.160	25	4635.903	21491600.720

(Table 5.4: Mean total numbers of artefacts for the whole dataset and each climatic phase)



(Fig 5.2: Box plots of the total artefact data presented in Table 5.4, showing the mean (x), and including data point distribution)

Results

Overall, it is clear there are no statistically significant relationships between the numbers of artefacts in the total assemblage between any of the periods (Kruskal-Wallis rank sum test: (H(2) = 0.801, df = 2, p-value = 0.670). However, the YD appears to have notably less numbers of artefacts compared with the Allerød and PB. This might suggest a higher number of larger sites during the Allerød and PB (indicating a higher level of residential mobility), and larger number of smaller sites during the YD (indicating a higher level of logistical mobility).

5.1d - Analysis of Percentage Microliths

Results

The results of the percentage microliths in the total assemblage are presented in Table 5.5 and for in the tool assemblage in Table 5.6. Statistical analysis is presented in A3.26 and A3.27 in Appendix 3.

Total Assemblage

	μ	**n**	**σ**	**σ^2**
Whole Dataset	1.897	83	3.597	12.939
Allerød	0.251	30	0.943	0.889
YD	0.663	28	2.379	5.661
PB	4.308	24	4.499	20.241

(Table 5.5: Weighted mean percentage of microliths in blank, core, and tool assemblage for the whole dataset and each climatic)

Tool Assemblage

	μ	**n**	**σ**	**σ^2**
Whole Dataset	14.067	126	23.672	560.386
Allerød	1.164	45	5.731	32.847
YD	5.176	37	10.818	117.035
PB	35.868	43	27.630	763.441

(Table 5.6: Weighted mean percentage of microliths in tool assemblage for the whole dataset and each climatic)

It was found from these two sets of analyses, there is a significant relationship between the periods (Kruskal-Wallis rank sum test: (H(2) = 37.825, df = 2, p-value = <0.00001); and (H(2) =

30.625, df = 2, p-value = <0.00001)), with a distinct increase in the percentage of microliths within assemblages from the PB compared with the YD (p=<0.00001; p=<0.00001) and the Allerød (p=<0.00001; p=0.00001). If we accept the number of microliths indicates the level of complexity, this strongly suggests a much higher level of complexity during the PB, pointing to a higher level of logistical mobility.

5.1d - Summary of Diversity Analysis

In terms of diversity, it appears there is a clearly more even distribution of tool types within assemblages from the YD indicating a more generalist, residential strategy, and a more uneven distribution of tools within assemblages from the Allerød and PB indicating a more specialist, logistical strategy. There was little difference noted between the richness values between any of the periods as the values were very similar.

There is also no strong evidence there were significant changes in the density of assemblages between any of the assemblages. However, the values tentatively suggest assemblages belonging to the Allerød had a higher number of artefacts per m^2 compared with the YD and PB. This might indicate populations during the Allerød practised a higher level of logistical mobility compared with the YD and PB. The site size results, again did not provide any strong evidence of any significant changes between periods, but the Allerød potentially has a notably higher number of artefacts than the YD and PB, while the YD potentially has a notably lower number of artefacts than the Allerød and PB. This might indicate populations during the Allerød practised a higher level of residential mobility, while populations during the YD practised a higher level of logistical mobility.

Finally, if we accept microliths are an indicator of complexity, it is clear populations during the PB show a notable, and significant, increase in complexity compared with both the Allerød and YD, indicating a shift to a much higher level of logistical mobility. Populations during the YD also display a higher level of complexity than the Allerød, but not to the same magnitude as the PB. This suggests there was a continued, significant increase in complexity from period to period, indicating an increase in logistical behaviour through time. However, this trend cannot be linked directly to climate change.

Overall, the results from this set of analyses show there appears to be a greater amount of strong evidence suggesting populations during the YD practised a distinctly more residential mobility compared with the Allerød and PB who seemed to have practised a more logistical mobility system.

5.2 - Expediency and Raw materials

5.2a - Analysis of the Blank to Tool Ratio

Results

When analysing the B/T ratio in the southern data, it was found the majority of sites were excavated post-1960, so it was decided there was no need to set a restriction on the data included.

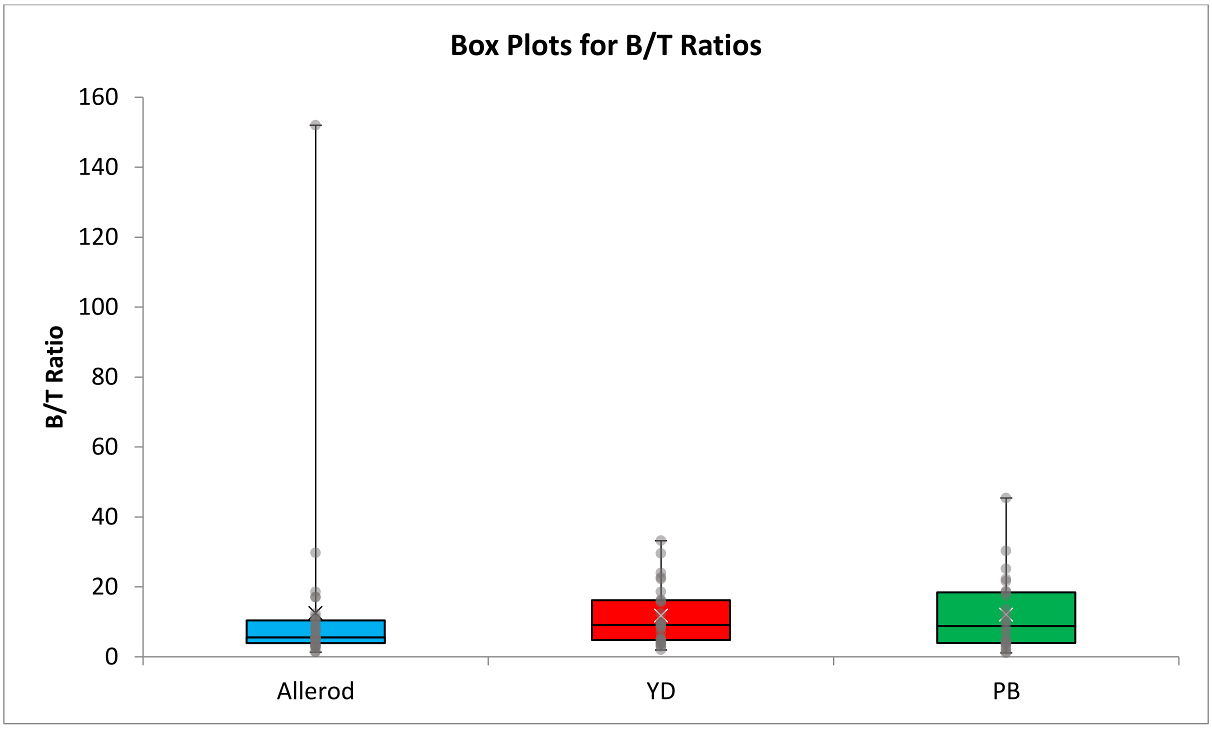
Table 5.7 and Fig 5.3 show the results of the mean B/T ratios for the whole dataset, the Allerod, YD, and PB. No transitional data is presented as the sample size of these phases were both too small and thus not suitable for comparison. Statistical analyses are presented in A3.28 in Appendix 3.

	μ	n	σ	σ^2
Whole Dataset	12.122	82	17.885	319.878
Allerød	12.487	31	26.597	707.424
YD	11.776	26	8.696	75.624
PB	12.029	25	10.781	116.224

(Table 5.7: Mean B/T ratio for the whole dataset and each climatic phase)

Analysis

There is no significant difference in the mean of the B/T ratio between any of the periods (Kruskal-Wallis rank sum test: ($H(2) = 2.073$, df = 2, p-value = 0.355). However, there is a decrease in the mean values during the YD, especially compared with the Allerød, tentatively suggesting a slight increase in mobility during this period. The YD also has a distinctly low variance which might support this, with little variation from site to site, which is indicative of a more residentially mobile strategy. In contrast, the Allerød has a distinctly higher variance which supports that populations during this period were more logistically organised, while the PB variance seems distinctly less than the Allerød, but larger than the YD.

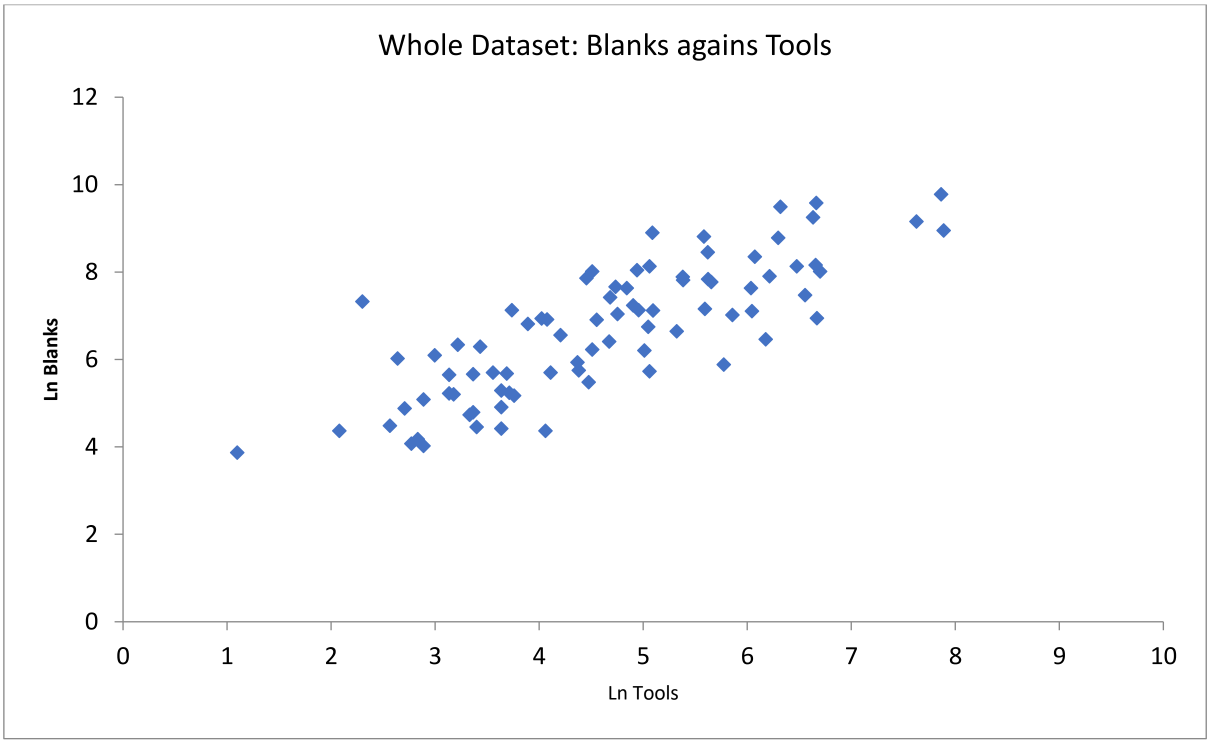


(Fig 5.3: Box plots of the B/T ratio data presented in Table 5.7, showing the mean (x), and including data point distribution)

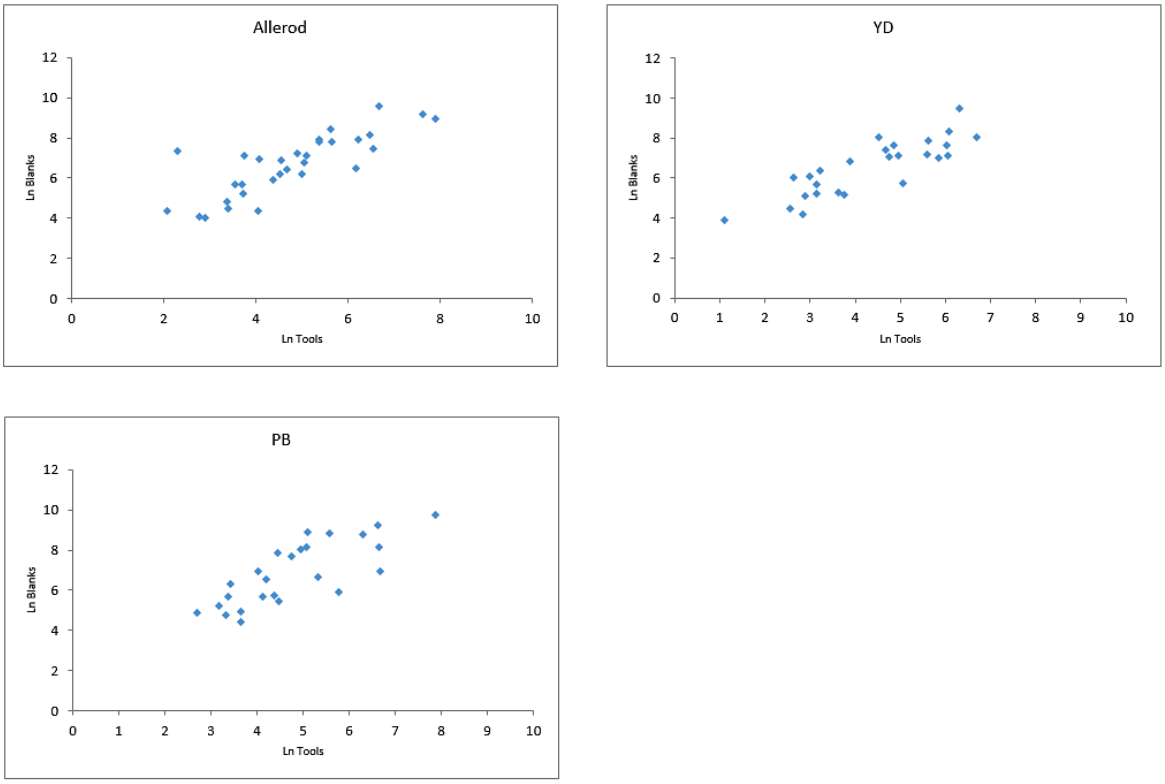
<u>Graphical Comparisons of Blanks against Tools</u>

Scatter plots were also produced in order to ascertain if there are any notable outliers and groupings which may further show changes in mobility strategies. Outliers may highlight potentially unique site types, while groupings may highlight sites used for different functions, such as, special task camps and base camps.

When comparing the blanks with tools graphically it can be seen, for the whole dataset (Fig 5.4), there is a strong, significant positive correlation. This shows, in general, the numbers of tools increase as the number of blanks increase. This strong correlation is also mirrored in the scatter plots for each of the climatic periods (Fig 5.5). There appear to be no distinct outliers.

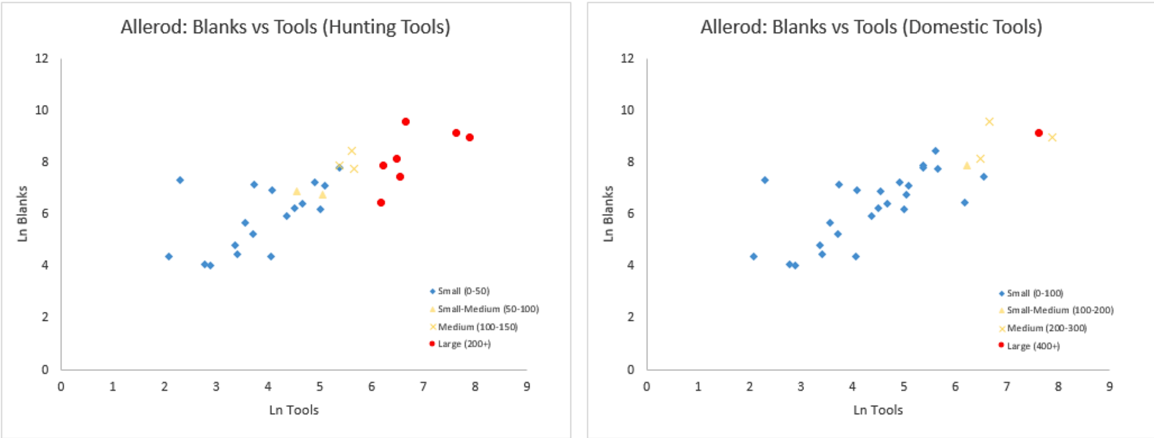


(Fig 5.4: Blanks against tools for the whole dataset)

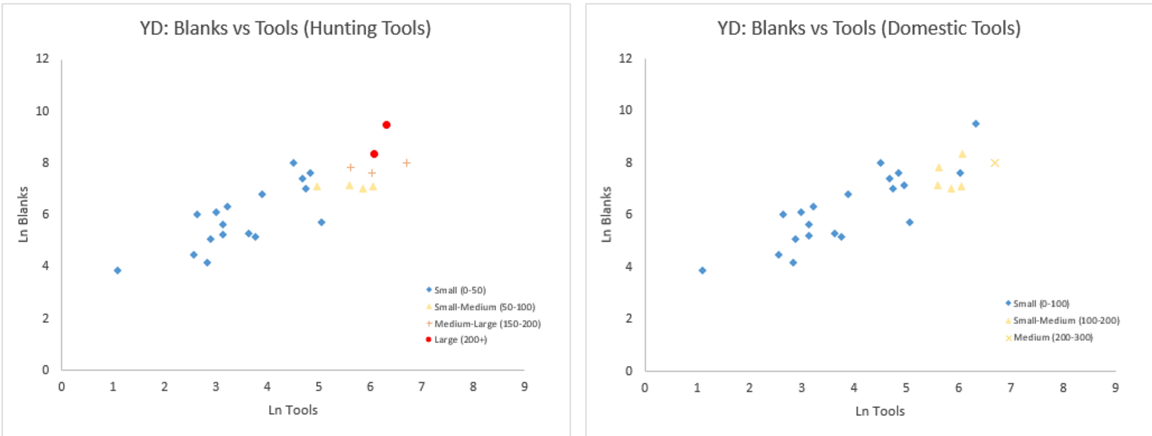


(Fig 5.5: Blanks against tool for each climatic phase)

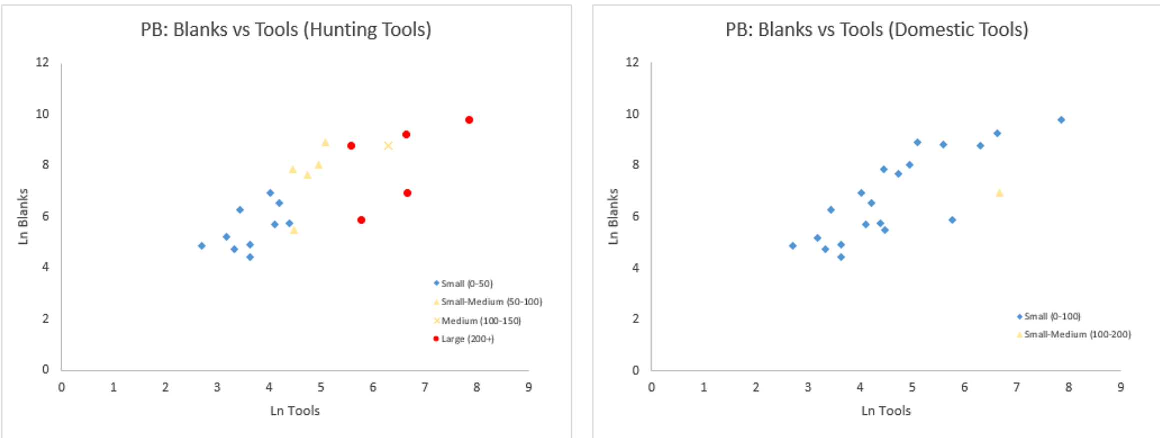
Numbers of Hunting and Domestic Tools



(Fig 5.6: The numbers of hunting tools and domestic tools in each assemblage in the Allerød sample)



(Fig 5.7: The numbers of hunting tools and domestic tools in each assemblage in the YD sample)



(Fig 5.8: The numbers of hunting tools and domestic tools in each assemblage in the PB sample)

It can be seen from Figs 5.6 to 5.8 the assemblages with larger numbers of blanks and tools generally contain the largest numbers of hunting and domestic tools, which one would expect. In each climatic phase, there is a higher proportion of sites with larger hunting tool components and smaller domestic tool components, which is different from the results of the northwest European sample. This suggests hunting might have been of equal importance throughout the Pleistocene/Holocene Transition. There is evidence of notably low domestic tool components during the PB and during the Allerød, which one might link to higher levels of logistical mobility. In contrast, the YD has a more equal number of hunting and domestic tools, which may indicate a comparatively more residential strategy, and correlates with the mean B/T ratio values. However, it should be noted this difference is much less distinct than the shift we see in the northwest European dataset, possibly indicating the more subdued response many expect at lower latitudes during the YD.

5.2b - Analysis of the Blank to Core Ratio

Results

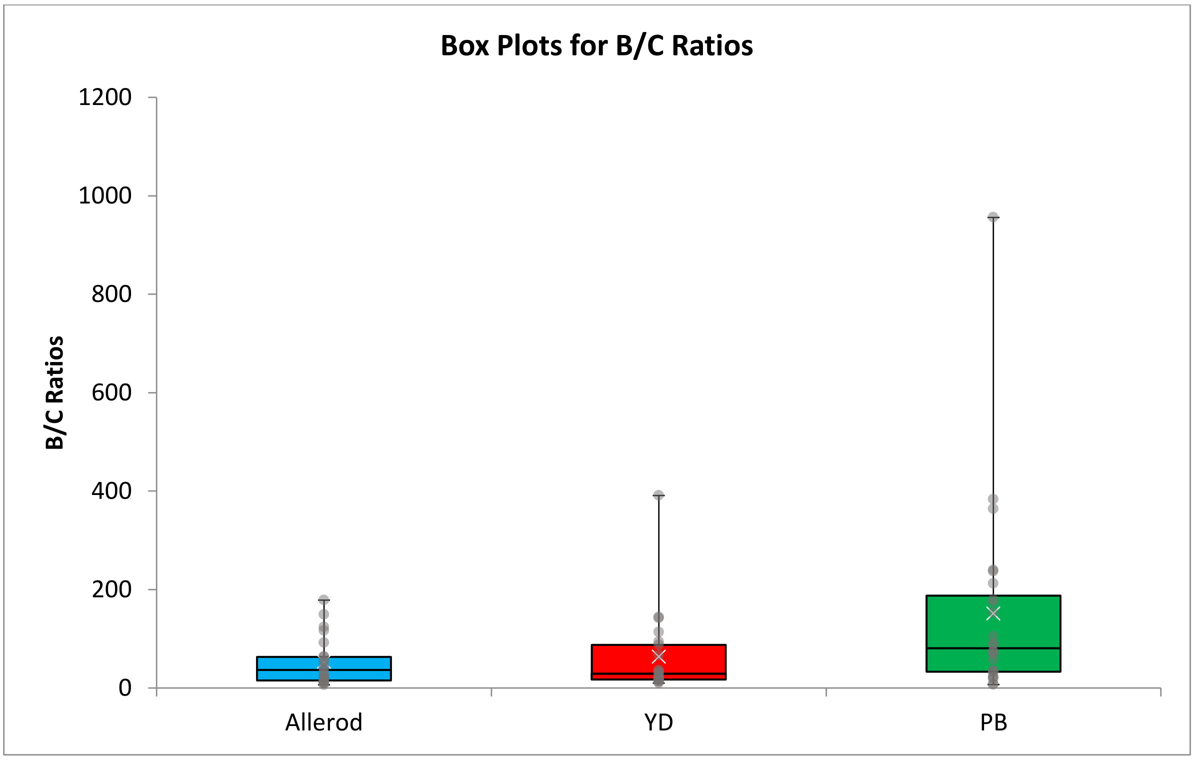
Table 5.8 and Fig 5.9 show the mean values for the blank to core ratios for the whole dataset and each of the climatic phases and their transitions.

	μ	n	σ	σ^2
Whole Dataset	91.564	67	138.958	19309.314
Allerød	52.796	22	49.328	2433.271
YD	63.689	21	86.518	7485.366
PB	151.493	24	201.950	40783.988

(Table 5.8: Mean B/C ratio for the whole dataset and each climatic phase)

Analysis

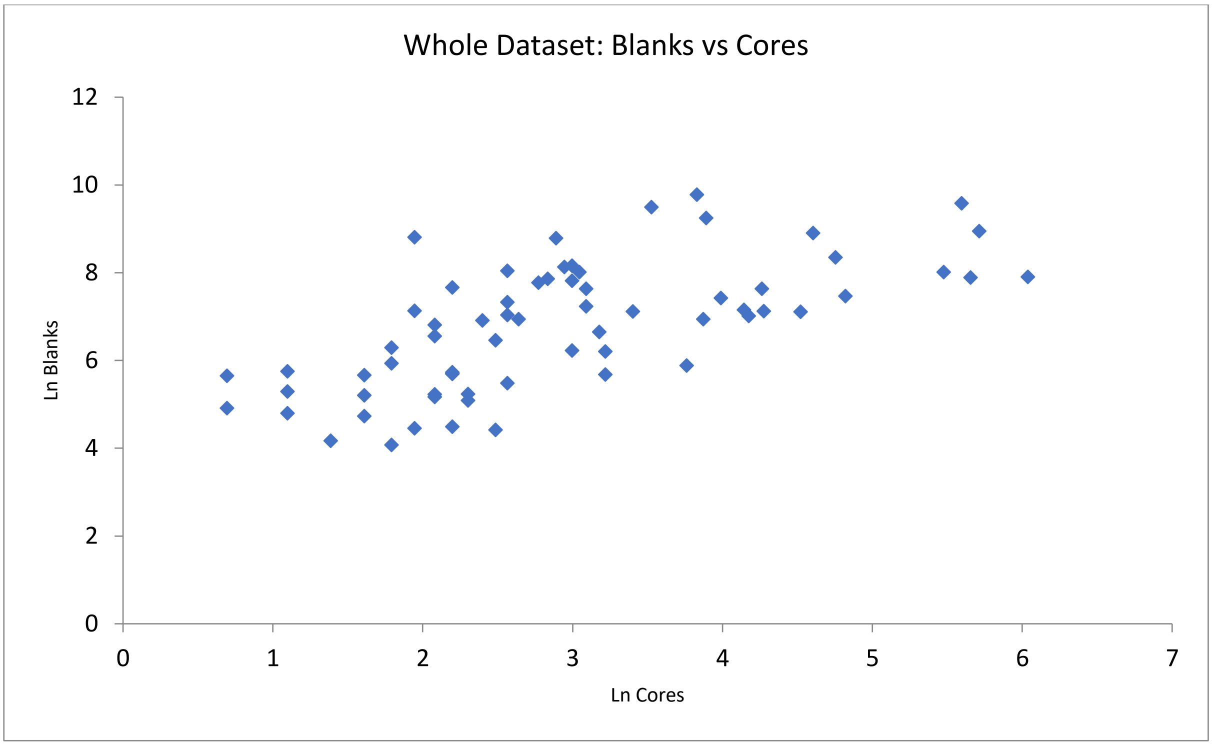
There was a significant relationship found between the periods (Kruskal-Wallis rank sum test: (H(2) = 7.193, df = 2, p-value = 0.027), but no significant difference between the Allerød and YD was found. However, there is a large, significant, increase in the mean values from the YD to the PB (p=0.024) and a significant increase in mean values between the Allerød and PB (p=0.019). This indicates populations during the PB were distinctly more logistically organised when compared with the Allerød and YD, which seem to have rather similar values. The PB also has a distinctly larger variance which further supports this interpretation, while the YD has a distinctly higher variance when compared with the Allerød. This potentially shows there was a small increase in logistical behaviour into the YD followed by a much larger shift into the PB. As there are no clear changes in and out of the YD and there is a significant increase in the B/C ratios between the Allerød and PB, there is no strong evidence any changes are linked directly to climate change.



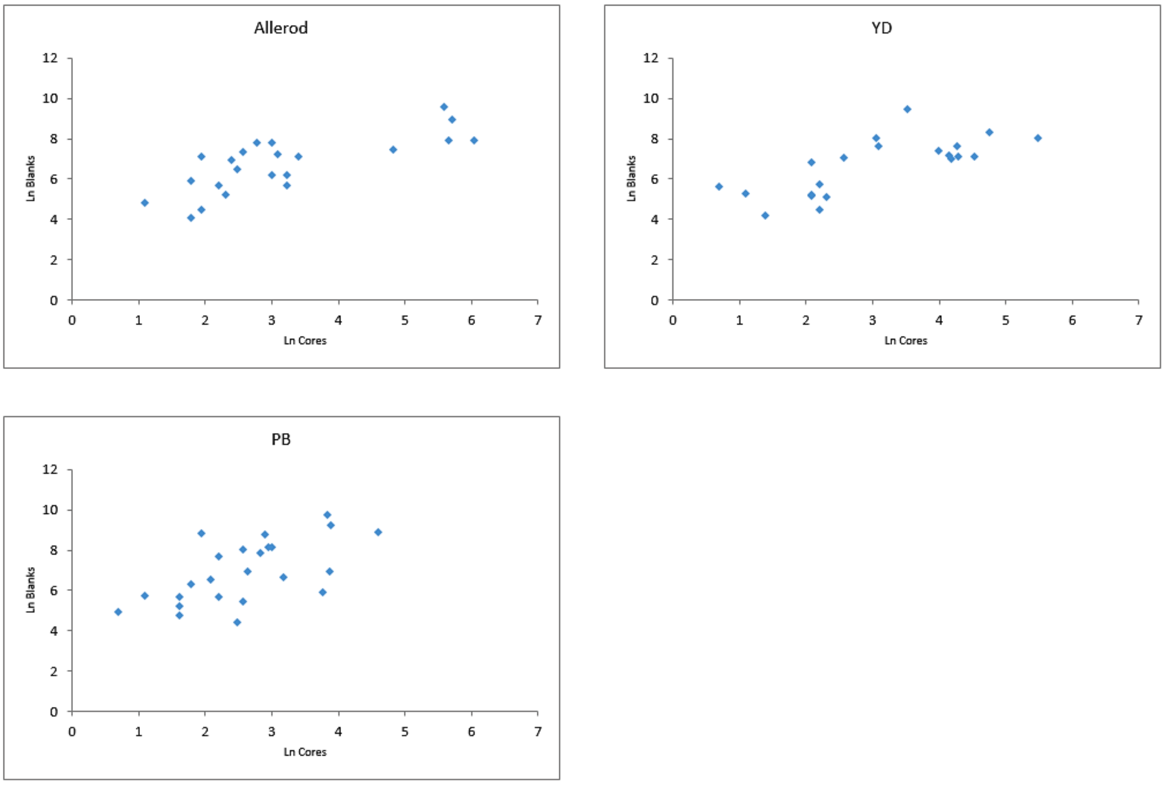
(Fig 5.9: Box plots of the B/C ratio data presented in Table 5.8, showing the mean (x), and including data point distribution)

<u>Graphical Comparisons of Blanks against Cores</u>

When comparing the blanks to cores graphically it can be seen, for the whole dataset (Fig 5.10), there is a fairly strong, significant, positive correlation. This shows, in general, the numbers of cores increase as the number of blanks increase. This fairly strong correlation is also mirrored in the scatter plots for each of the climatic periods (Fig 5.11). There appear to be no distinct outliers.

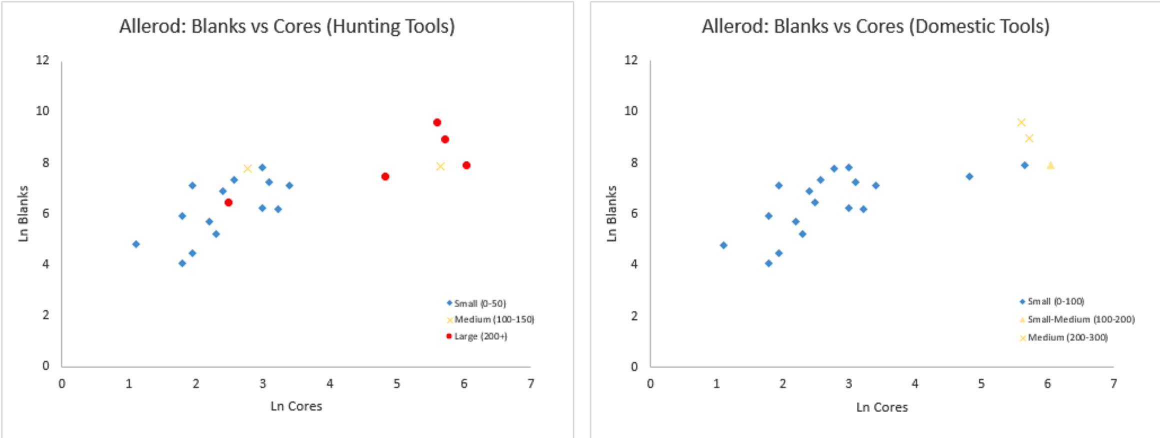


(Fig 5.10: Blanks against cores for the whole dataset)

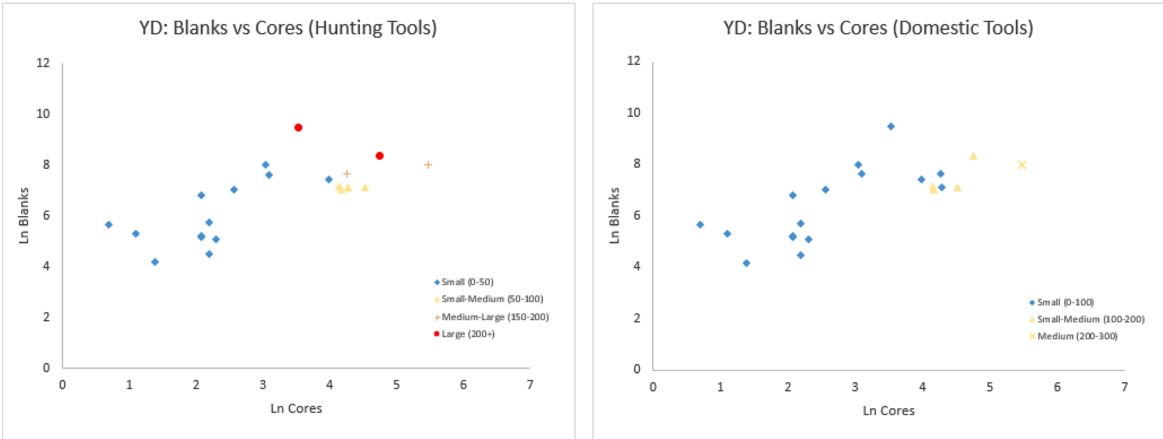


(Fig 5.11: Blanks against cores for each climatic phase)

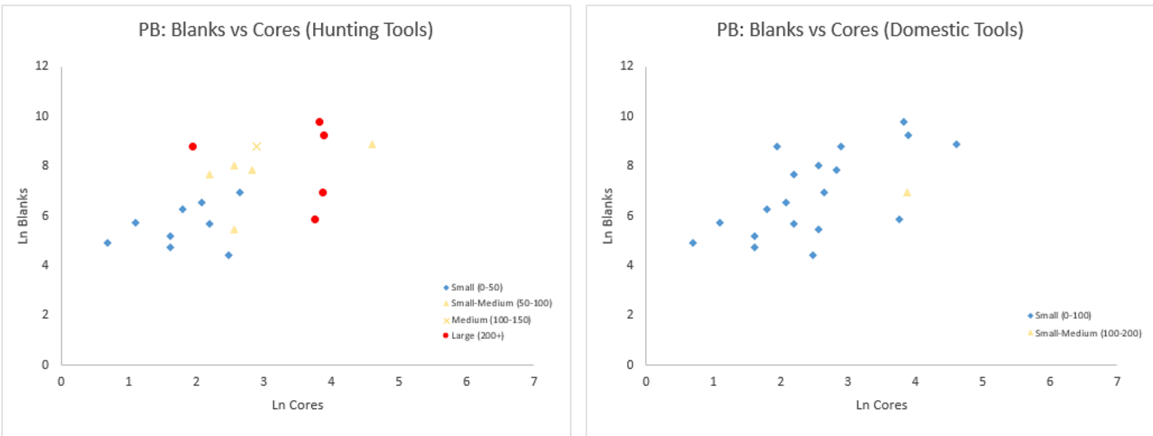
Numbers of Hunting and Domestic Tools



(Fig 5.12: The numbers of hunting tools and domestic tools in each assemblage in the Allerød sample)



(Fig 5.13: The numbers of hunting tools and domestic tools in each assemblage in the YD sample)



(Fig 5.14: The numbers of hunting tools and domestic tools in each assemblage in the PB sample)

Figs 5.12 to 5.14 show again there is a correlation with the assemblages with the highest number of blanks and cores having the largest numbers of hunting and domestic tools. It again is shown hunting tools are a more important component of the tool assemblage in each period, more so in the Allerød and PB, and to a lesser extent in the YD. This again shows the potential of the human populations during the Allerød and PB practised a relatively more logistically mobile strategy and a more residential strategy during the YD.

Analysis of Percentage of Retouched and Utilised Blanks

Table 5.9 and 5.10 show the mean values for the percentage of retouched and utilised blanks for the whole dataset and each of the climatic phases and their transitions in the total assemblage and tool assemblage respectively. The statistical analysis can be seen in A3.31 and A3.32 in Appendix 3.

Total Assemblage

Results

	μ	**n**	**σ**	**σ²**
Whole Dataset	0.704	57	1.401	1.964
Allerød	0.588	20	0.700	0.490
YD	1.416	20	1.575	2.482
PB	0.364	15	0.889	0.789

(Table 5.9: Weighted mean of the percentage of retouched and utilised blanks in the total assemblage for the whole dataset and each climatic phase)

Analysis

There was found to be a significant relationship between the climatic periods (Kruskal-Wallis rank sum test: (H(2) = 11.057, df = 2, p-value = 0.004), with a significant decrease in the mean values from the YD to the PB (p=0.003) and a significant decrease between the Allerød and PB (p=0.009), suggesting populations during the PB practised a lower level of expediency possibly related to an increase in residential mobility when compared with both the YD and the Allerød. There does appear to be an increase in the mean values during the YD when compared with the Allerød and PB, which might suggest an increase in expediency and an increase in logistical mobility within the populations of this period.

Tool Assemblage

Results

	μ	n	σ	σ^2
Whole Dataset	8.699	80	7.396	54.695
Allerød	7.378	26	6.028	36.331
YD	12.676	24	8.888	79.001
PB	7.070	24	6.949	48.288

(Table 5.10: Weighted mean of the percentage of retouched and utilised blanks in the tool assemblage for the whole dataset and each climatic phase)

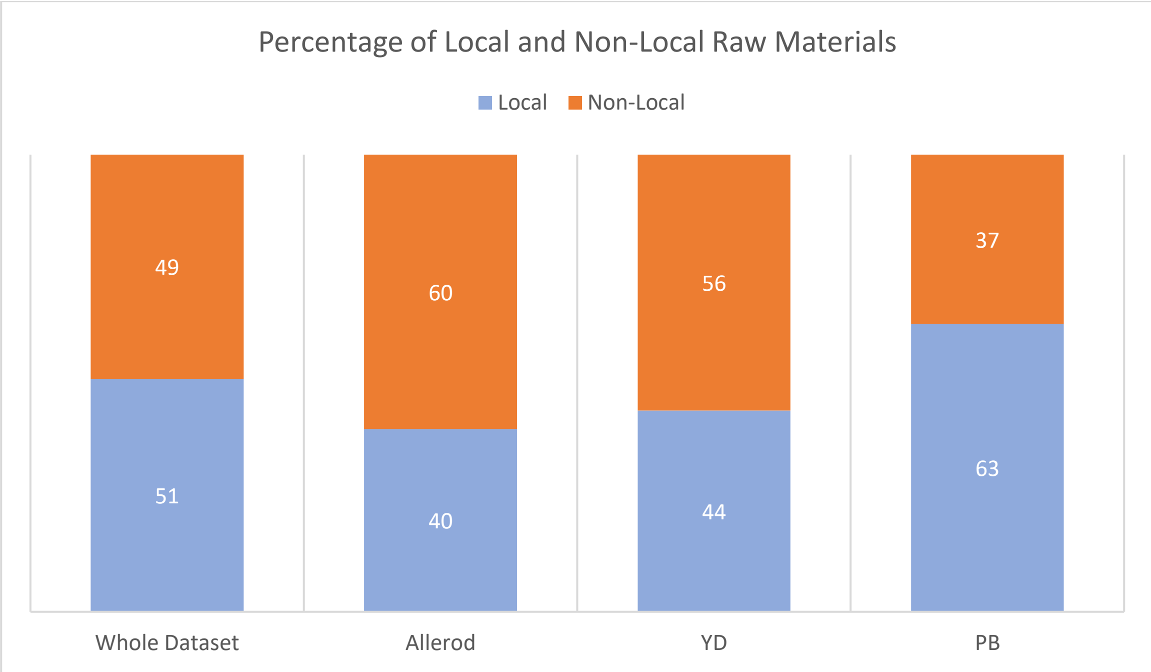
Analysis

There is a near significant relationship between periods when only the tools are considered (Kruskal-Wallis rank sum test: ($H(2) = 5.830$, df = 2, p-value = 0.054), but there is a significant decrease in the percentage of utilised and retouched tools from the YD into the PB ($p=0.020$) suggesting a decrease in the level of expediency in populations during the PB, possibly in a more residentially mobile system. However, as there is no significant change from the Allerød to the YD and between the Allerød and PB, these changes appear not to be related directly to climate change.

5.2d - Summary of Expediency Analysis

There is no significantly significant difference between the B/T ratio in any of the three periods, which suggests there was no significant change in the level of tool expediency from the Allerød into the YD and through to the PB. However, the PB has a significantly higher B/C ratio than both the Allerød and YD, suggesting there was a dramatic shift to a more expedient tool manufacturing strategy during the early Holocene, but the PB also has a significantly lower percentage of URB's than both the Allerød and YD, suggesting there was significantly less use of expedient, unmodified blanks as tools. These inconsistent indications during the PB cannot be linked directly to the climate changes related to the YD. Overall, the results of the expediency analysis appear to show a subdued response to the YD stadial.

5.2e - Raw Material Procurement



(Fig 5.15: The numbers of assemblages with predominantly local or predominantly non-local raw materials for each climatic phase)

Detailed information on raw material procurement was not reliably reported in many of the published reports. Thus, to maximise the sample size, a simple classification of "predominately local" and "predominately non-local" was applied to the data, as this was the most commonly reported information. Importantly, it should be noted this classification is extremely subjective to each publication and its research history/culture in the country of origin along with the geology of the region a site is located.

	Percentage Local Raw Materials	n	Percentage Non-Local Raw Materials	n	Total Percentage	n
Whole Dataset	51.163	22	48.837	21	100	43
Allerød	40.000	6	60.000	9	100	15
YD	44.444	4	55.556	5	100	9
PB	63.158	12	36.842	7	100	19

(Table 5.11: Percentage of sites with predominately local and predominately non-local raw material sources)

It appears, from Table 5.11 and Fig 5.15, there is a notably higher percentage of local raw materials during the PB with the YD having a slightly higher percentage of local raw materials than the Allerød. The sample sizes are quite small so interpretations must be made with caution, but this might indicate a small shift to a more logistical system from the Allerød to the YD and a much larger shift to a more logistical system from the YD to the PB. These results show there appears to be no relation to climate change and changes in raw material provenance.

5.2f - Analysis of the Tool to Core Ratio

Analysis

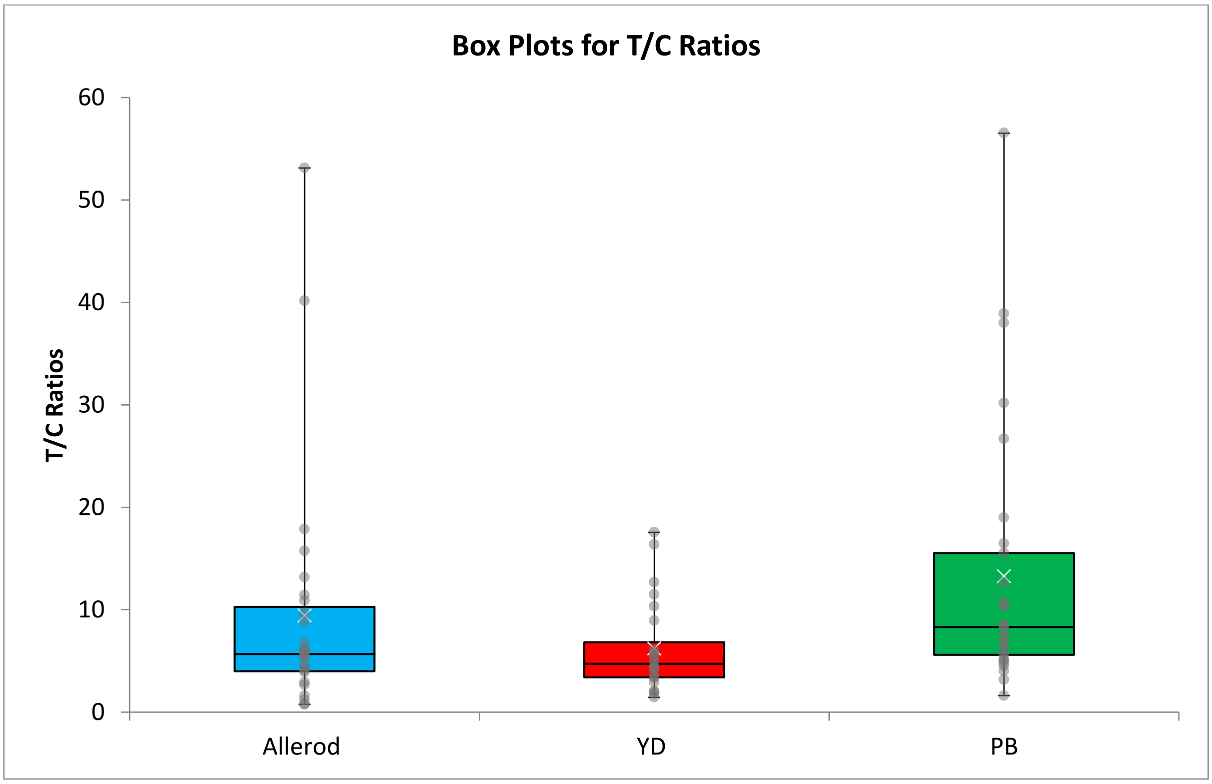
Table 5.12 and Fig 5.16 present the results of the mean T/C ratios, with the statistical analyses presented in A3.33 in Appendix 3.

	μ	**n**	**σ**	**σ^2**
Whole Dataset	9.856	80	10.881	118.391
Allerød	9.432	27	11.710	137.1130
YD	6.200	24	4.442	19.735
PB	13.276	29	12.913	166.752

(Table 5.12: Mean T/C ratio for the whole dataset and each climatic phase)

Results

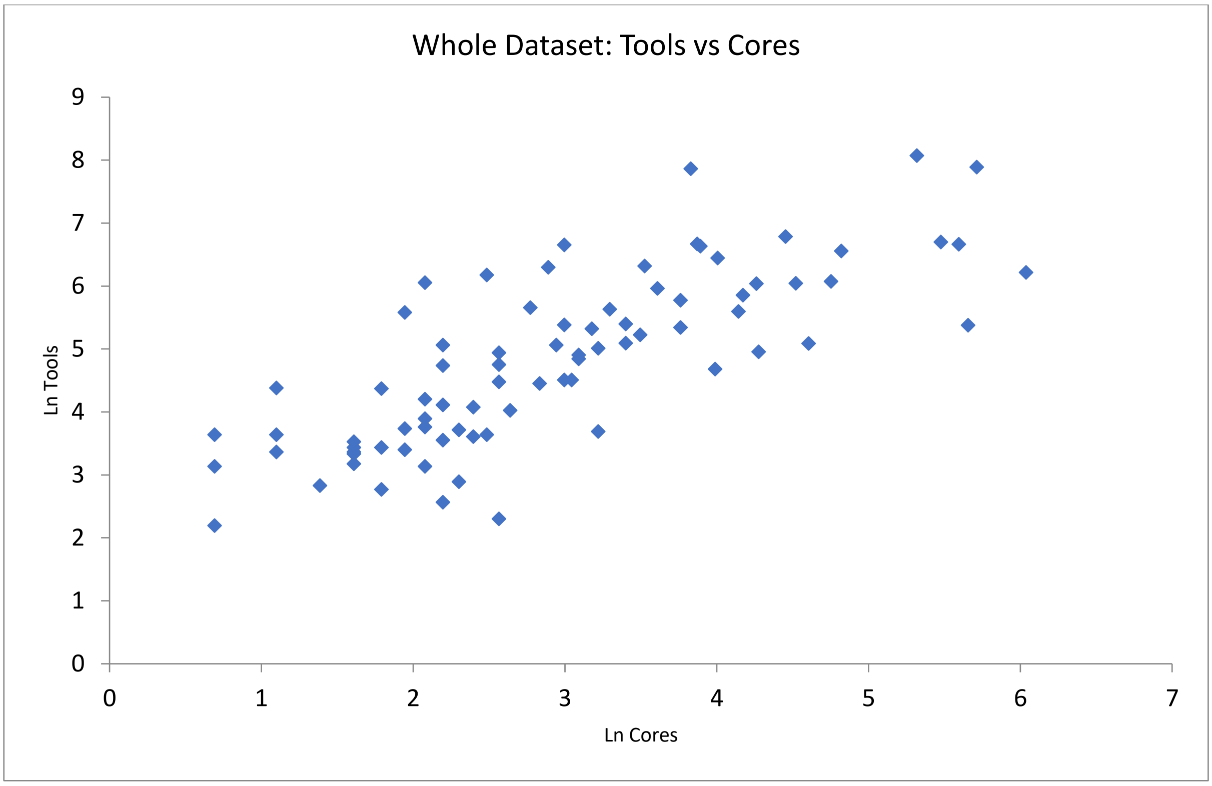
There was found to be a statistically significant relationship between the climatic phases (Kruskal-Wallis rank sum test: (H(2) = 5 8.242, df = 2, p-value = 0.016), with the PB having a significantly greater mean T/C ratio than the YD (p=0.004), but no statistically significant difference to the Allerød. This might indicate there was a more economical use of cores, with fewer cores producing a greater number of tools during the PB. However, this also may be a consequence of more logistical sites with dedicated special task camps where there would be mostly tools and few or no cores present. This seems more likely when considering the previous results? There is also a notable, although not significant, decrease in the mean values from the Allerød into the YD which might suggest there was a decrease in the economical use of raw materials during the YD, compared with the Allerød and PB, which indicates an increase in more wasteful, expedient tool manufacturing strategies characteristic of a more logistical system.



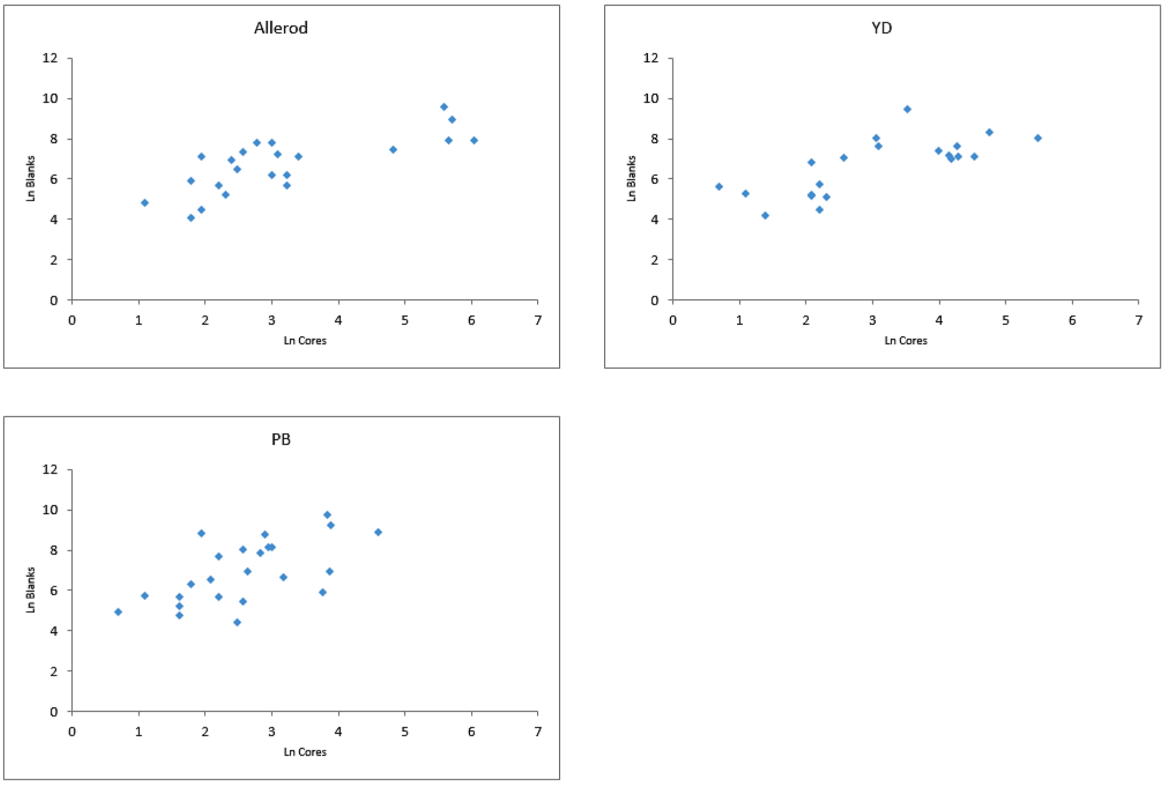
(Fig 5.16: Box plots of the T/C ratio data presented in Table 5.12, showing the mean (x), and including data point distribution)

<u>Graphical Comparisons of Blanks against Cores</u>

When comparing the tools with cores graphically it can be seen, for the whole dataset (Fig 5.17), there is a fairly strong, significant, positive correlation. This shows, in general, the numbers of cores increase as the number of tools increase. This fairly strong correlation is also mirrored in the scatter plots for each of the climatic periods (Fig 5.18). There appear to be no distinct outliers.

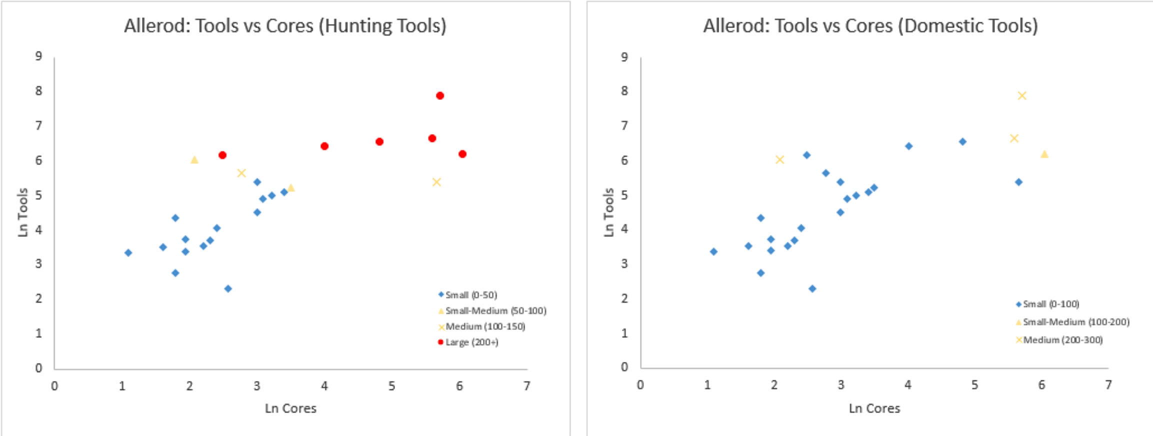


(Fig 5.17: Tools against cores for the whole dataset)

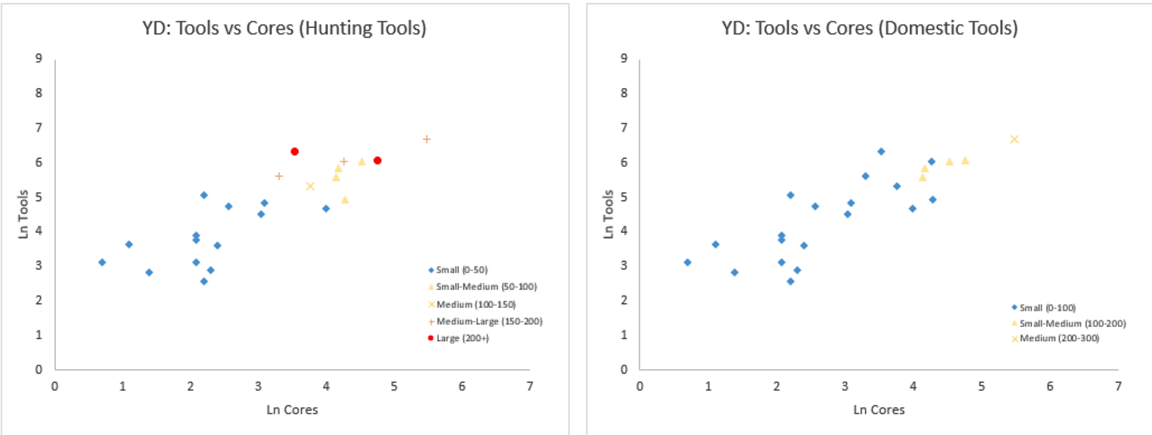


(Fig 5.18: Tools against cores for each climatic phase)

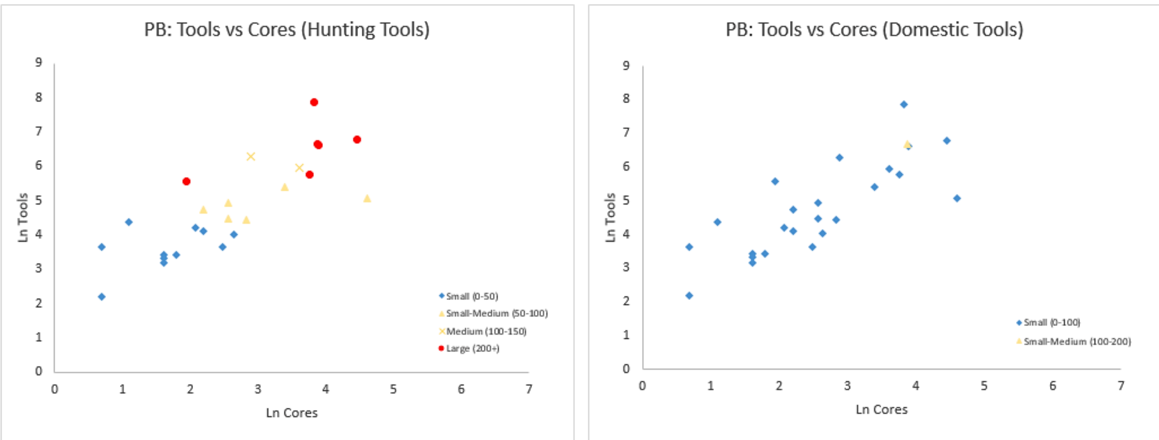
Numbers of Hunting and Domestic Tools



(Fig 5.19: The numbers of hunting tools and domestic tools in each assemblage in the Allerød sample)



(Fig 5.20: The numbers of hunting tools and domestic tools in each assemblage in the YD sample)



(Fig 5.21: The numbers of hunting tools and domestic tools in each assemblage in the PB sample)

Once again its can be seen the assemblages with the largest numbers of tools and cores have the highest numbers of hunting and domestic tools (Figs 5.19 to 5.21). This again shows hunting tools appear to be more important at a greater number of sites throughout the climatic phases with the Allerød and PB having a greater number of distinctly larger hunting tool components in assemblages. The YD again has comparatively similar numbers of hunting and domestic tool components suggesting a slight shift to a more residential strategy which might be supported by the previous analyses. Again, the comparatively subtle shift in this data is in contrast to that seen in the northwest sample, further supporting a more subdued response during the YD.

5.2g - Summary of Raw Material Analysis

The YD appears to have a lower percentage of sites with raw materials from a predominately local source compared with the Allerød and especially the PB. This could hint at populations during the YD being less mobile than those in the Allerød and PB, with the populations during the PB being especially more mobile. However, the samples sizes are notably small and thus this interpretation should be viewed with caution.

There is no significant difference in the mean of the B/T ratio between any of the periods suggesting there was no change in the distance from raw material sources and thus no obvious change in mobility strategy. However, there is a notable decrease in the mean values during the YD, especially compared with the Allerød, which tentatively suggests a slight decrease in the distance to raw material sources during this period and an increase in logistical behaviour.

It can be seen from the B/C ratio values, there are no significant differences between the Allerød and YD, indicating there was little change in the mean distance from raw material sources between these periods, and thereby no obvious change in mobility. However, there is a potentially significant increase in the mean values from the YD to the PB and a significant increase in mean values between the Allerød and PB, which indicates there was a shift to behaviours more consistent with populations at a lesser distance from raw material sources (more logistically mobile) from the YD to the PB, and populations during the PB Interstadial were at lesser distances from raw material sources (again more logistically mobile) than during the Allerød interstadial. There is no strong evidence that any changes are linked directly to climate change.

The PB has a significantly greater mean T/C ratio than either the YD or the Allerød. This might indicate there was a more economical use of cores, with fewer cores producing a greater number of tools. This suggests a more residential strategy was in place during the PB. There is also a notable, although not significant, decrease in the mean values from the Allerød into the YD which might suggest there was a decrease in the economical use of raw materials during the YD, compared with the Allerød and PB and indicate an increase in more wasteful, expedient tool manufacturing strategies characteristic of a more logistical system.

The B/C ratio values suggest there was a significant shift to a more expedient strategy during the PB, which might be supported by the values from the B/T ratios. This indicates populations during the PB utilised disparate or low quality raw materials. When observing the raw material quality (Fig 5.8), it appears sites during the PB had a higher proportion of variable quality raw materials than compared with both the Allerød and YD, along with a smaller representation of good and high quality raw materials. Perhaps the greater use of an expedient toolkit is related to the greater number of sites with variable quality raw material sources than the Allerød and YD? The Allerød, in particular, has a notably larger number of sites that exploited high quality raw materials.

Overall, the results of the raw material analyses are inconclusive. However, there is again strong support that at least the PB populations were significantly more logistically organised than the YD, most likely using poorer quality raw materials to create a more expedient toolkit.

5.3 - Site Type Analysis

The expected characteristics of base camps and special task camps were outlined in Chapter 4 in tables 4.14 and 4.15 along with the expected values for high, medium, low levels of each indicator in which each assemblage was categorised in table 4.16. Table 5.35 shows the results when these expectations are applied to the database for the southern European sample.

	No. Base Camps	% Base Camps	No. Special Task Camps	% Special Task Camps	n Total	% Total
Whole Dataset	36	33.33	72	66.67	108	100
Allerød	13	33.33	26	66.67	39	36.11
YD	16	48.48	17	51.52	33	30.56
PB	7	19.44	29	80.56	36	33.33

(Table 5.13: Number and percentage of base camps and special task camps recognised using the parameters set out in table 4.16 in Chapter 4 for the whole database and each climatic phase)

Looking at these results it appears the PB has a distinctly lower number of base camps compared with the Allerød and YD and a distinctly lower percentage of base camps to special task camps than the Allerød and YD. These results indicate a much higher level of logistical mobility was practised by populations during the PB. In contrast, the YD has a much more even percentage of base camps and special task camps, suggesting populations during this period practised a higher level of residential mobility than the Allerød and PB. The Allerød lies in between these two periods in terms of the percentages of base camps and special task camps, but suggests a higher level of logistical mobility was practised by populations during this period than the YD, but lower than during the PB. Overall, it appears there was a notable shift to a more residential mobility system during the YD from the Allerød, and a large shift to a more logistical system from the YD to the PB.

When comparing these results with the northwest data, there appears to be a distinct reversal in these patterns. The northwest data indicates there was a distinct shift from a more residentially mobile system during the Allerød, to a distinctly more logistical strategy during the YD, and then back to a more residentially mobile system during the PB, while the populations during the PB seem to be less residentially mobile than the Allerød.

Table 4.42 in Chapter 4, sets out the expectations of expediency for base camps in a residential strategy, base camps in a logistical strategy, and special task camps. These were then applied to the south data. If we accept, from the results in Table 5.35, that populations during the Allerød and PB practised a more logistically mobile strategy, and populations during the YD practised a more residentially mobile strategy, then we would expect, from the expectations set out in table 4.42 in Chapter 4, the Allerød and PB to have base camps with a higher blank to tool, and blank to core ratio, and a lower tool to core ratio, than base camps during the YD. The next section will look at the differences between the Allerød and PB base and special task camps and the YD base and special task camps.

5.3a - Base Camps

If sites can be classified as base camps then their compositions would be expected to change if mobility changes with the change in climate into the YD. Base camps in a logistical system should have a distinct range of values representing a more expedient strategy with larger base camps which are occupied for longer periods and moved less frequently than with a more residential system. Table 5.14 show the results of the comparisons of the mean B/T, B/C, and T/C ratios for the assemblages designated as base camps between the Allerød, YD, and PB, and the statistical analyses are presented in A3.34-A3.36 in Appendix 3.

	Allerød Base Camps				YD Base Camps				PB Base Camps			
Indicator	n	μ	σ	$σ^2$	n	μ	σ	$σ^2$	n	μ	σ	$σ^2$
B/T Ratio	9	6.033	3.022	9.133	14	9.388	6.521	42.522	3	3.278	0.979	0.958
B/C Ratio	9	40.409	22.325	498.423	13	50.190	44.958	2021.196	3	32.572	31.693	1004.416
T/C Ratio	10	7.279	4.445	19.758	14	7.647	7.440	55.347	5	7.693	6.425	41.285

(Table 5.14: Mean B/T, B/C, and T/C ratios for the assemblages classed as base camps for each climatic phase)

No significant relationships were found between any of the periods in the B/T, B/C, and T/C ratios (Kruskal-Wallis rank sum test: B/T = (H(2) = 0.776, df = 2, p-value = 0.679); B/C = (H(2) = 0.235, df = 2, p-value = 0.889); and T/C = (H(2) = 0.568, df = 2, p-value = 0.753)). Unfortunately, the sample sizes for the indicators for the Allerød and especially the PB were too low to generate reliable results when comparing base camps values between them and the YD. These results are therefore inconclusive. However, the fact so few assemblages could be identified as base camps for the Allerød and PB does suggest there is an unusually low number of these site types in the south data.

5.3b - Special Task Camps

If these sites are classified as logistical camps then their compositions would not be expected to be significantly different from each other between each climate phase as one would expect a special task camp to retain similar characteristics whatever the level of residential or logistical mobility is being practised. Table 5.15 shows the results of the comparisons of the mean B/T, B/C, and T/C ratios for the assemblages designated as special task camps between the Allerød, YD, and PB. The statistical analyses are presented in A3.37-A3.39 in Appendix 3.

	Allerød Special Task Camps				YD Special Task Camps				PB Special Task Camps			
Indicator	n	μ	σ	σ^2	n	μ	σ	σ^2	n	μ	σ	σ^2
B/T Ratio	21	15.498	32.061	1027.886	12	14.563	10.290	105.892	18	13.949	11.557	133.563
B/C Ratio	15	66.674	55.122	3038.401	9	139.111	201.621	40651.201	17	181.991	230.953	53339.232
T/C Ratio	18	11.260	14.811	219.357	11	8.579	7.767	60.325	19	14.457	14.050	197.402

(Table 5.15: Mean B/T, B/C, and T/C ratios for the assemblages classed as special task camps for each climatic phase)

No significant relationships were found between any of the ratios between any of the climatic periods (Kruskal-Wallis rank sum test: B/T = (H(2) = 3.369, df = 2, p-value = 0.186); B/C = (H(2) = 3.481, df = 2, p-value = 0.175); and T/C = (H(2) = 2.934, df = 2, p-value = 0.231)). However, although not significant, it would appear the B/C ratios in the Allerød are notably lower than the YD and especially the PB and with lower variances, suggesting populations during this phase may have been more residentially mobile.

5.3c - Comparison of Base camps and Special Task Camps

It would be expected, for each climatic period, the base camp ratio values should be significantly different from the special task camp values, representing the different functions assumed to be carried out at these site types. The results of the comparisons of base camps and special task camps for each period are presented in Tables 5.16-5-5.18, and the statistical analysis presented in A3.40-A3.42 in Appendix 3.

Allerød

	Allerød Base Camps				Allerød Special Task Camps			
Indicator	n	μ	σ	$σ^2$	n	μ	σ	$σ^2$
B/T Ratio	9	6.033	3.022	9.133	21	15.498	32.061	1027.886
B/C Ratio	9	40.409	22.325	498.423	15	66.674	55.122	3038.401
T/C Ratio	9	7.279	4.445	19.758	18	11.260	14.811	219.357

(Table 5.16: Mean B/T, B/C, and T/C ratios for the assemblages classed as base camps and special task camps for the Allerød)

Younger Dryas

	YD Base Camps				YD Special Task Camps			
Indicator	n	μ	σ	$σ^2$	n	μ	σ	$σ^2$
B/T Ratio	14	9.388	6.521	42.522	12	14.563	10.290	105.892
B/C Ratio	13	50.190	44.958	2021.196	9	139.111	201.621	40651.201
T/C Ratio	14	7.647	7.440	55.347	11	8.579	7.767	60.325

(Table 5.17: Mean B/T, B/C, and T/C ratios for the assemblages classed as base camps and special task camps for the YD)

Preboreal

	PB Base Camps				PB Special Task Camps			
Indicator	n	μ	σ	$σ^2$	n	μ	σ	$σ^2$
B/T Ratio	3	3.278	0.979	0.958	18	13.949	11.557	133.563
B/C Ratio	3	32.572	31.693	1004.416	17	181.991	230.953	53339.232
T/C Ratio	5	7.693	6.425	41.285	19	14.457	14.050	197.402

(Table 5.18: Mean B/T, B/C, and T/C ratios for the assemblages classed as base camps and special task camps for the PB)

5.3d - Summary of Site Type Analysis

Overall, if the allocation of site types is accepted, there is a notably lower number of base camps and a higher number of special task camps during the PB. This strongly suggests populations during this period were much more logistically organised than those in the YD and the Allerød. The YD also has a notably low number of special task camps, and the numbers of base camps and special task camps are almost identical (n = 16 and n= 17 respectively). This strongly indicates populations during the YD were more residentially organised compared with the populations from the Allerød and PB. The Allerød has double the number of special task camps to the number of base camps, suggesting populations during the Allerød were more logistically mobile than those during the YD. This evidence points to populations practising a more logistical strategy during the Allerød and especially the PB, and more residentially mobile strategies during the YD, and supports the generalised conclusions of the previous analyses.

There were no significant differences found between the B/T, B/C, and T/C values of the designated base camps and designated special task camps in any of the periods. However, unfortunately, the sample sizes were particularly low for these analyses, and interpretations should not be made from these results.

The same problem was encountered when comparing the base camps with the special task camps for each of the periods, with no significant differences found from small sample sizes, particularly in the Allerød and PB datasets. However, the YD has a more robust sample size, and provides a non-significant result, suggesting there was little difference in assemblage composition between base camps and special task camps during the YD. This is similar to that found within the north-western dataset.

5.4 - Conclusion

The results of this chapter appear to generally point to a slight shift from less mobile populations practising a more logistical strategy during the Allerød, to more mobile populations in a more residential strategy during the YD, and reverting back to a particularly more logistical system during the PB. This is mainly shown through the richness and B/T ratio values and site type analysis, whereas the B/C and T/C ratios appear to be less significantly different between periods, which may suggest the differences between lithic assemblages may have been more subdued than in the northwest dataset.

However, due to the general lack of significance in the differences between the Allerød and YD indicators, along with the evidence showing only the slightest shift, it is likely there was no real major change in mobility from the Allerød into the YD. In contrast, the PB indicators are generally much more notable and statistically different, suggesting the major change in mobility occurred during the early Holocene, to a notably more logistically mobile system.

This tentative result is the opposite of that seen within the northwest dataset, where there appears to be more mobile populations practising a more distinctly residential strategy during the Allerød and PB interstadials, and distinctly less mobile populations practising a more logistical strategy during the YD stadial. It should also be noted, in general, these "mobility shifts" between periods appear to be more subdued in the south dataset, especially in the case of the B/T, B/C, and T/C ratio values, which might be a factor of the more muted effects of the YD in the southern regions of Europe.

Overall, there is a much more subdued shift, possibly from a more logistical strategy in the Allerød to a more residential strategy in the YD, followed by a major shift to a more logistical mobility strategy into the PB. In the south, climate change appears not to have any significant effect on the composition of tool assemblages, and thereby it can be assumed on human populations.

In Chapter 6, the results of the north-western and southern analyses will be directly compared, to ascertain if these observations are significantly different from each other, and if there is evidence of significantly different mobility strategies in north Europe.

Chapter 6: Comparison of the North-western and Southern European Analysis

In Chapters 4 and 5 the indicators for mobility were applied to the northwest and southern European datasets individually. It was found there is strong evidence the two regions responded differently. The northwest dataset indicated a shift from a more residential strategy in the Allerød, to a more logistical mobility during the YD, followed by a return to a more residential mobility during the PB, although one that was less so than the previous interstadial. However, the south dataset indicated a reverse pattern of a more logistical strategy during the Allerød, a more residential mobility during the YD, and a return to a particularly more logistical mobility during the PB. The southern dataset also provides evidence of a more subdued response to the YD with the shifts in the ratio and diversity values appearing to be less distinct than in the northwest dataset.

To ascertain whether there is a statistically significant difference between the assemblages of the northwest and southern datasets a direct comparison of each indicator from each period in both regions must be carried out. With the results of the sets of analyses from Chapter 4 and 5, one might expect the assemblages in the northwest region would differ significantly from those of the south. This set of results will follow the same format as Chapters 4 and 5, beginning with diversity.

6.1 - Tool Diversity Indicators

6.1a - Analysis of Richness (NTAXA)

The results of the NTAXA analysis are presented in Table 6.1, while the statistical analysis is presented in A3.43 in Appendix 3.

N.W.	μ	n	σ	σ^2	**S.**	μ	n	σ	σ^2
Whole Dataset	7.475	245	2.394	5.730	Whole Dataset	7.751	131	1.934	3.739
Allerød	7.444	79	1.948	3.795	Allerød	7.179	45	1.796	3.224
YD	6.847	45	1.744	3.041	YD	8.660	37	2.579	6.652
PB	8.270	70	2.313	5.349	PB	8.084	39	1.494	2.233

(Table 6.1: Comparison of the northwest and south weighted mean NTAXA results)

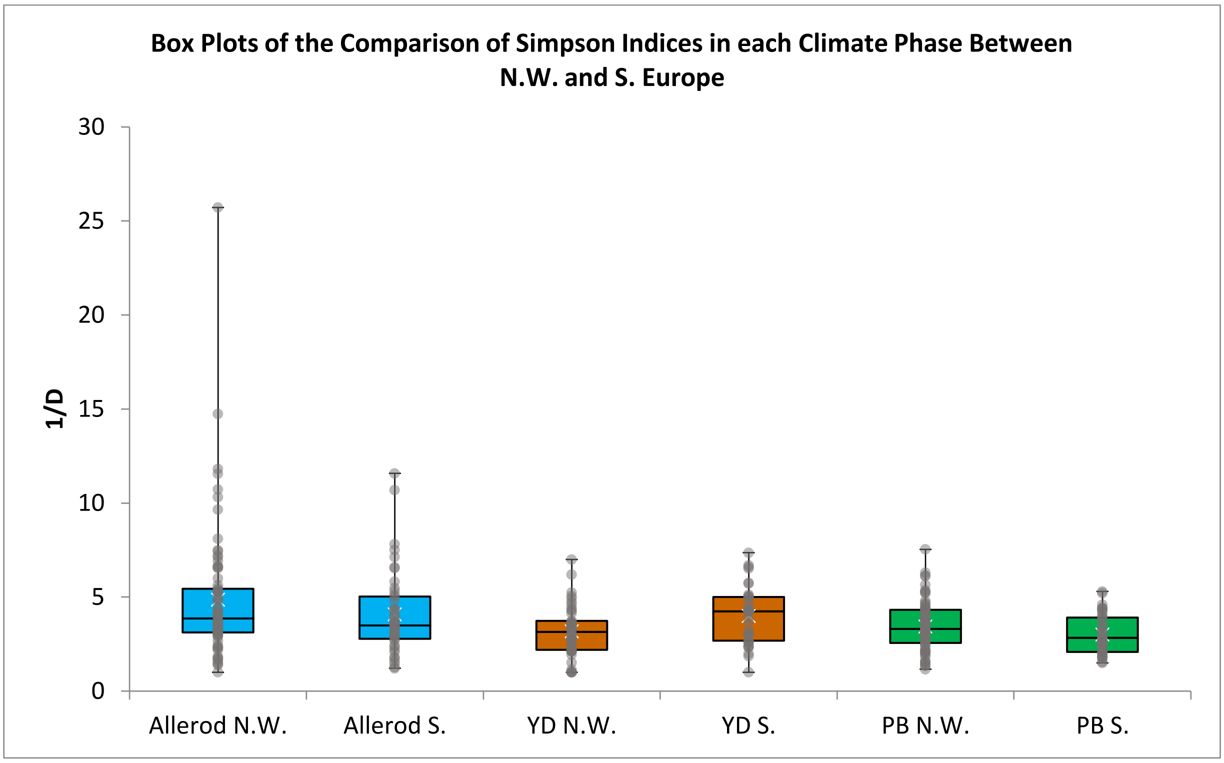
When comparing these results with the northwest data, it was found the mean richness values of the south Allerød and YD assemblages are significantly statistically higher than the north-western Allerød and YD assemblages ($p=0.0018$ and $p=0.041$ respectively), while the PB does not appear to be significantly different in either sets of data, albeit with a slightly higher value in the northwest data which might indicate there is a difference in the mean richness during this period as well. This suggests assemblages in the south dataset have, on average, a greater number of tool types in their assemblages, indicating a higher level of residential mobility, especially in the YD dataset, and also potentially a lower level of mobility (perhaps more logistical) during the PB. It should also be noted the variance of the YD sample is distinctly higher in the south which supports the presence of more logistical populations during this period, with a greater variation in the numbers of tools in assemblages. This might imply a larger number of different camp sites would be expected in a logistical system. There is also a notably larger variance in the PB in the northwest sample which might support the possibility a more logistical system was in place during this period, while the variance of the south PB is notably small, which suggests there was little variation in the numbers of tools between assemblages. This would be more characteristic of a residential system.

6.1b – Analysis of Evenness

The results of the comparison of Simpson Index values are presented in Table 6.2 and Fig 6.1, and the statistical analysis is presented in A3.44 in Appendix 3.

N.W.	μ	n	σ	$σ^2$	S.	μ	n	σ	$σ^2$
Whole Dataset	3.859	244	2.452	6.013	Whole Dataset	3.704	131	1.714	2.936
Allerød	4.869	78	3.526	12.430	Allerød	4.094	45	2.249	5.057
YD	3.191	45	1.357	1.841	YD	3.997	37	1.506	2.269
PB	3.441	70	1.338	1.790	PB	3.018	39	1.057	1.116

(Table 6.2: Comparison of the northwest and south mean evenness results)



(Fig 6.1: Box plots of the comparisons of the Simpson Index values for each climatic phase between the northwest (N.W.) and south (S.) datasets)

When comparing these results with the northwest data, it can be seen only the south YD assemblages significantly differ from the northwest YD assemblages (p=0.020), with the south displaying larger mean values. This suggests, during the YD in the south, there was a greater level of evenness, and thereby a greater level of residential mobility than in assemblages from the northwest during the same period. There appears to be no significant difference between the south and the northwest during the Allerød and PB, although the south Allerød has a notably lower mean value than the northwest which might indicate a higher level of specialisation, and a lower level of mobility, in the south during the Allerød. In both sets of data, the Allerød period has a notably higher variance, which suggest there was a wider variation of evenness in assemblages, which might indicate populations were more logistically organised during this period in both regions.

6.1c – Analysis of Density

Total Artefacts per m^2

The results of the total number of artefacts per m^2 are presented in Table 6.3, and the statistical analyses are given in A3.45 in Appendix 3.

N.W.	μ	n	σ	$σ^2$	S.	μ	n	σ	$σ^2$
Whole Dataset	44.124	147	127.224	16185.898	Whole Dataset	163.670	81	290.220	84227.817
Allerød	20.620	45	36.526	1334.179	Allerød	192.776	30	306.915	94196.831
YD	64.391	31	126.895	16102.322	YD	148.378	23	343.585	118050.490
PB	67.565	41	205.330	42160.274	PB	161.274	24	239.589	57402.872

(Table 6.3: Comparison of the northwest and south mean density in the total assemblage results)

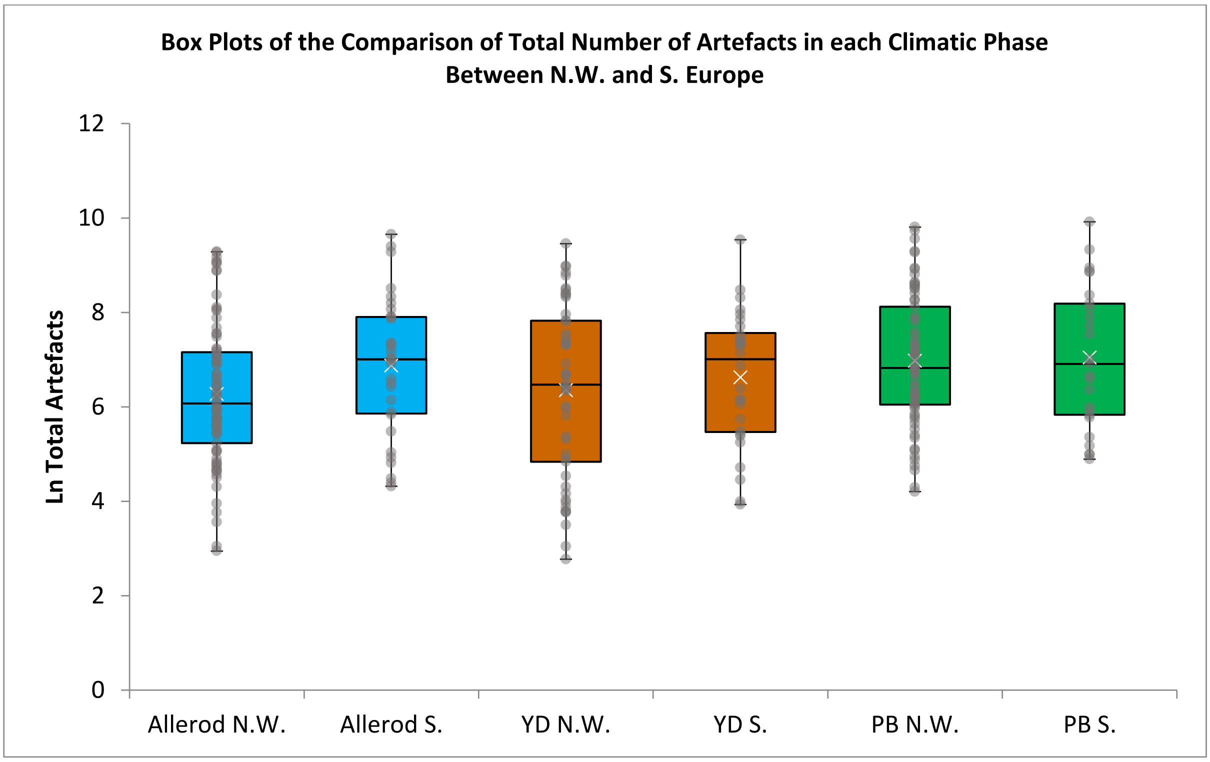
It can be seen the southern assemblages have statistically significantly larger densities during the Allerød ($p=<0.00004$) and PB ($p=0.006$), while the YD also has a notably higher mean density, although not to any statistical significance. This would suggest during the Allerød and PB in the south, more logistical practises were carried out, with a higher number of smaller, more densely concentrated sites. There is also a notably larger variance in artefact density in the south sample, especially in the Allerød and YD datasets. This suggests there was considerably more variation in site densities in the south during the Allerød and YD periods, which might indicate a more logistical strategy being in place in the south during these phases.

Total Number of Artefacts

The results of the analysis of the total number of tools are presented below in Table 6.4 and Fig 6.2, while the statistical analyses are provided in A3.46 in Appendix 3.

N.W.	μ	n	σ	$σ^2$	S.	μ	n	σ	$σ^2$
Whole Dataset	2038.286	248	3668.293	13456374.640	Whole Dataset	2300.211	90	3624.332	13135785.920
Allerød	1581.922	77	2666.936	7112545.994	Allerød	2463.484	31	3716.148	13809756.260
YD	1950.633	49	2723.366	7416721.279	YD	1746.000	28	2693.750	7256290.296
PB	2621.928	69	3859.262	14893904.070	PB	3104.160	25	4635.903	21491600.720

(Table 6.4: Comparison of the northwest and south mean total numbers of blanks, cores, and tools results)



(Fig 6.2: Box plots of the comparisons of the total number of artefacts for each climatic phase between the N.W and S. datasets)

The results show there is a borderline significant difference in the sizes of assemblages in the Allerød between the two regions (p=0.055), with the southern sites containing many more artefacts than the north-western sites. However, there is no statistically significant difference between the two regions during the YD and PB. This suggests populations during the Allerød in the southern region occupied larger camps, or stayed for longer durations.

6.1d - Analysis of Percentage Microliths

The results of the percentage microliths in the total and tool assemblages are presented in Tables 6.5 and 6.6, and the statistical analyses are presented in A3.47 and A3.48 in Appendix 3.

Total Assemblage

N.W.	μ	n	σ	$σ^2$	**S.**	μ	n	σ	$σ^2$
Whole Dataset	0.556	248	1.109	1.229	Whole Dataset	1.897	83	3.597	12.939
Allerød	0.044	77	0.128	0.016	Allerød	0.251	30	0.943	0.889
YD	0.336	49	0.707	0.500	YD	0.663	28	2.379	5.661
PB	1.291	69	1.460	2.132	PB	4.308	24	4.499	20.241

(Table 6.5: Comparison of the northwest and south mean percentage microliths in the total assemblage results)

Tool Assemblage

N.W.	μ	n	σ	$σ^2$	**S.**	μ	n	σ	$σ^2$
Whole Dataset	10.573	261	21.051	443.130	Whole Dataset	14.067	126	23.672	560.386
Allerød	0.296	82	0.766	0.587	Allerød	1.164	45	5.731	32.847
YD	5.016	46	8.782	77.120	YD	5.176	37	10.818	117.035
PB	14.825	75	18.918	357.894	PB	35.868	43	27.630	763.441

(Table 6.6: Comparison of the northwest and south mean percentage of microliths in the tool assemblage results)

When compared with the northwest data, the south PB sites have significantly higher mean percentages of microliths in the total assemblage (p=0.007), suggesting populations during the south PB were more logistically mobile than the northwest. However, there are no statistically significant differences between the regions when looking at the percentage within the tool assemblage. Although the northwest and south YD have notably similar mean percentages, possibly indicating a similar level of logistical mobility between each region during this phase.

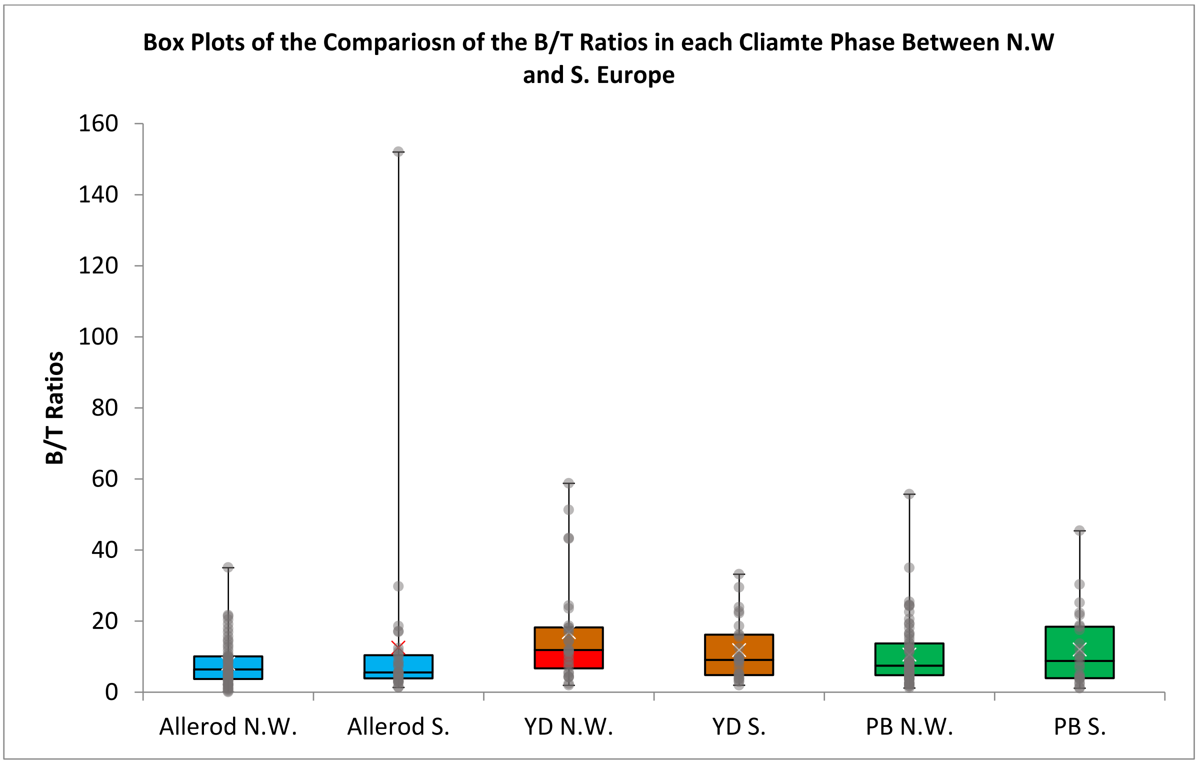
6.2 - Expediency and Raw Materials

6.2a - Analysis of the Blank to Tool Ratio

The results of the B/T ratio analyses are given in Table 6.7 and Fig 6.3, and the statistical analyses are provided in A3.49 in Appendix 3.

N.W.	μ	n	σ	σ²	S.	μ	n	σ	σ²
Whole Dataset	13.289	195	18.141	329.091	Whole Dataset	12.122	82	17.885	319.878
Allerød	8.179	58	6.555	42.967	Allerød	12.487	31	26.597	707.424
YD	16.814	28	14.922	222.680	YD	11.776	26	8.696	75.624
PB	10.554	63	9.259	85.728	PB	12.029	25	10.781	116.224

(Table 6.7: Comparison of the northwest and south mean B/T ratio results)



(Fig 6.3: Box plots of the comparisons of the B/T ratios for each climatic phase between the N.W. and S. datasets)

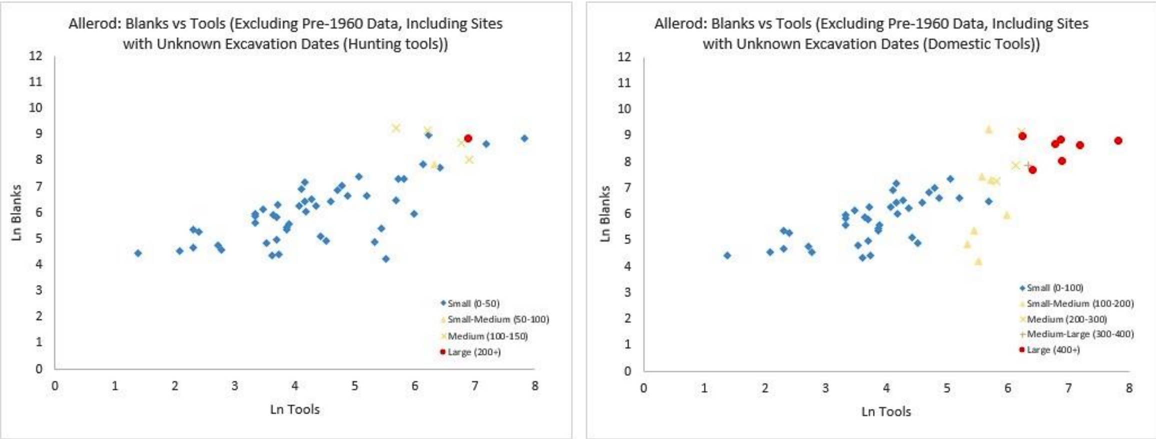
The results of this analysis found no statistically significant difference between the B/T ratios of the two regions, which suggests the assemblages should be characteristically similar in the northwest and south. However, it is notable the south dataset has higher B/T values during the Allerød and PB, and distinctly lower values during the YD. This might provide evidence populations were more logistically mobile during the interstadial phases and more residentially mobile during the YD in the south. It can be seen the difference between the shifts in values of each sequential climatic phase are much more subdued in the south dataset when compared with the northwest.

There is a notably higher variance in the south Allerød dataset which might suggest there was a greater variation in the B/T ratio between assemblages, which might indicate a more logistical system was in place in the region during this phase, which does not support the interpretation of the mean B/T ratios. There is also a notably higher variance in the northwest YD dataset which again might indicate a more logistical system was being employed in this region during the YD. This is supported by the interpretation of mean B/T values.

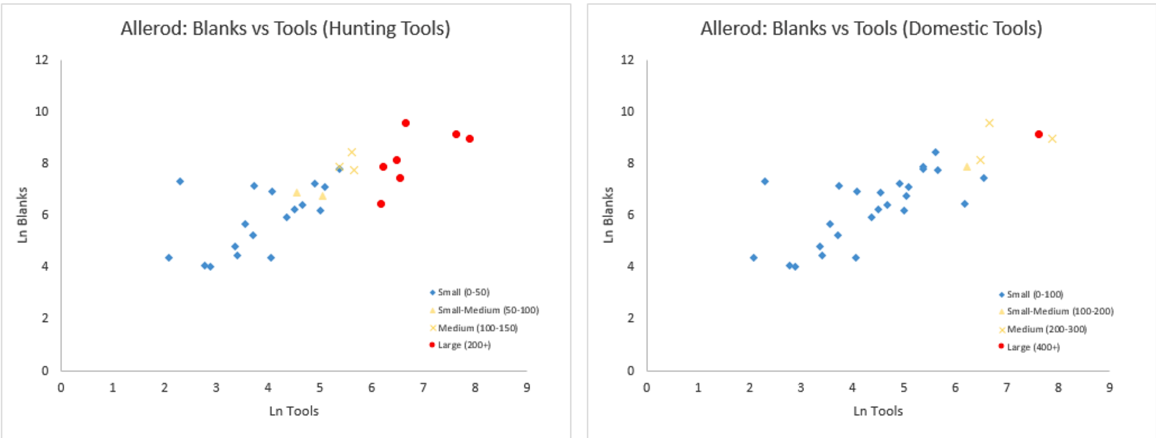
Numbers of Hunting and Domestic Tools

Figs 6.4 to 6.6 compare the distribution of blanks against cores and plot hunting and domestic tools as a third variable. It appears there are distinctly more assemblages within the south dataset having higher proportions of hunting tools compared with domestic tools during the Allerød and to some extent the PB phases. This suggests hunting was a more important activity during these periods in the south, and potentially points to a higher level of logistical mobility. The results of northwest Allerød and PB suggest a higher level of residential mobility was employed during these periods. However, there is no such clear difference observed between the northwest and south datasets within the YD, suggesting a similar level of mobility was employed in both regions during this period. This also shows hunting tools seem less important during the YD in the south when compared with the Allerød and YD, possibly indicating a comparatively more residential mobility strategy during this phase.

Northwest

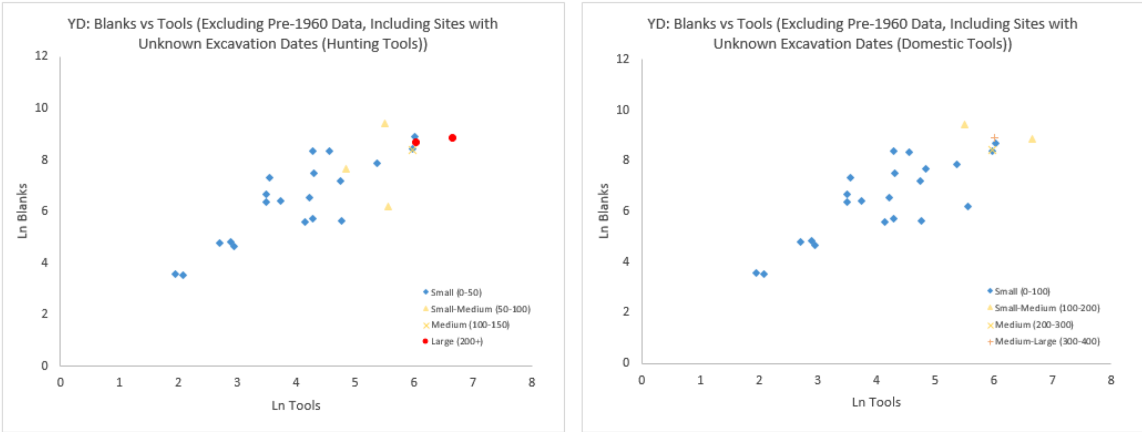


South

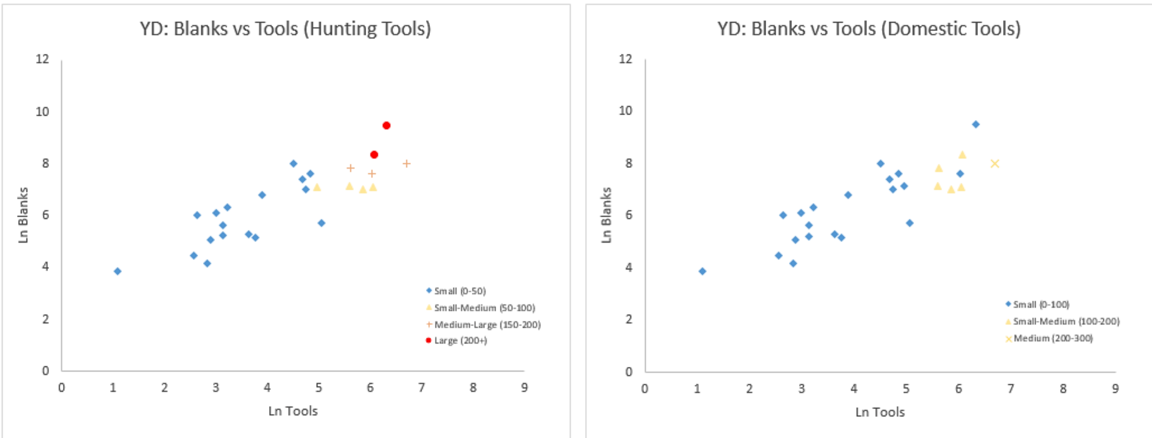


(Fig 6.4: Comparison of the numbers of hunting tools and domestic tools within assemblages between the N.W. and S. Allerød sample)

Northwest

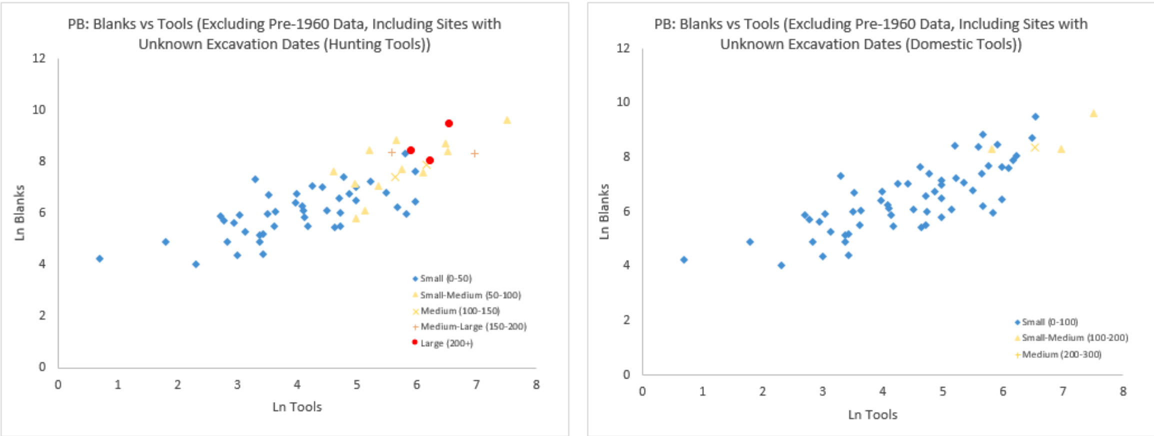


South

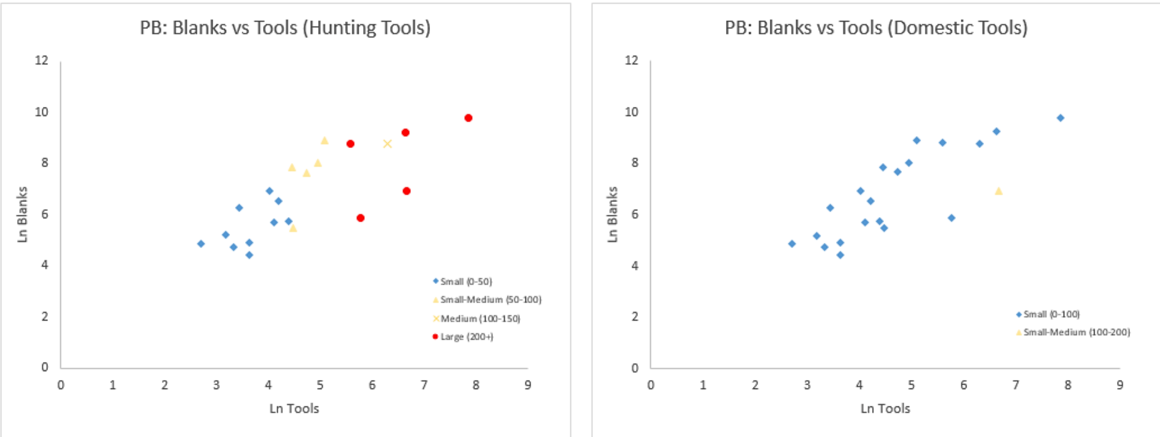


(Fig 6.5: Comparison of the numbers of hunting tools and domestic tools within assemblages between the N.W. and S. YD sample)

Northwest



South



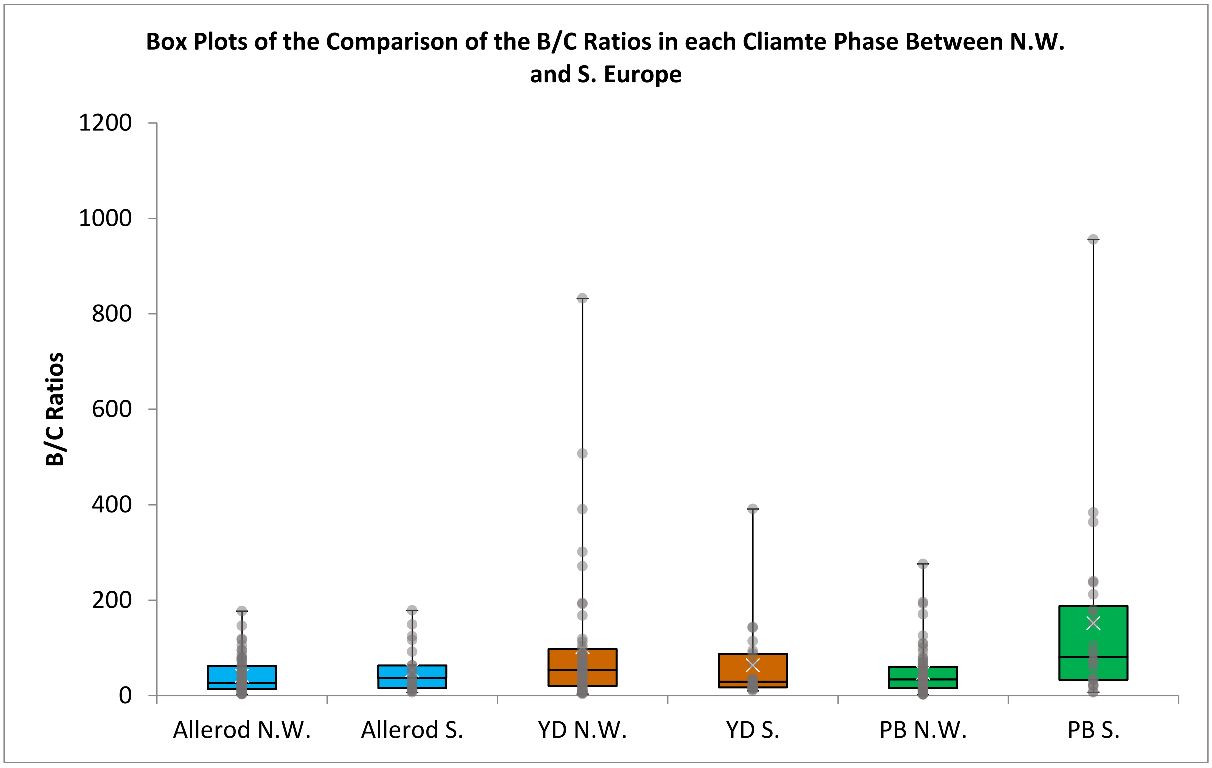
(Fig 6.6: Comparison of the numbers of hunting tools and domestic tools within assemblages between the N.W. and S. PB sample)

6.2b – Analysis of the Blank to Core Ratio

The results of the comparison of the B/C ratios are presented in Table 6.8 and Fig 6.7, while the statistics are presented in A3.50 in Appendix 3.

N.W.	**μ**	**n**	**σ**	**σ^2**	**S.**	**μ**	**n**	**σ**	**σ^2**
Whole Dataset	57.437	201	87.006	7570.052	Whole Dataset	91.564	67	138.958	19309.314
Allerød	36.288	54	35.321	1247.579	Allerød	52.796	22	49.328	2433.271
YD	107.821	40	160.556	25778.171	YD	63.689	21	86.518	7485.366
PB	44.799	62	48.985	2399.568	PB	151.493	24	201.950	40783.988

(Table 6.8: Comparison of the northwest and south mean B/C ratio results)



(Fig 6.7: Box plots of the comparisons of the B/C ratios for each climatic phase between the N.W. and S. datasets)

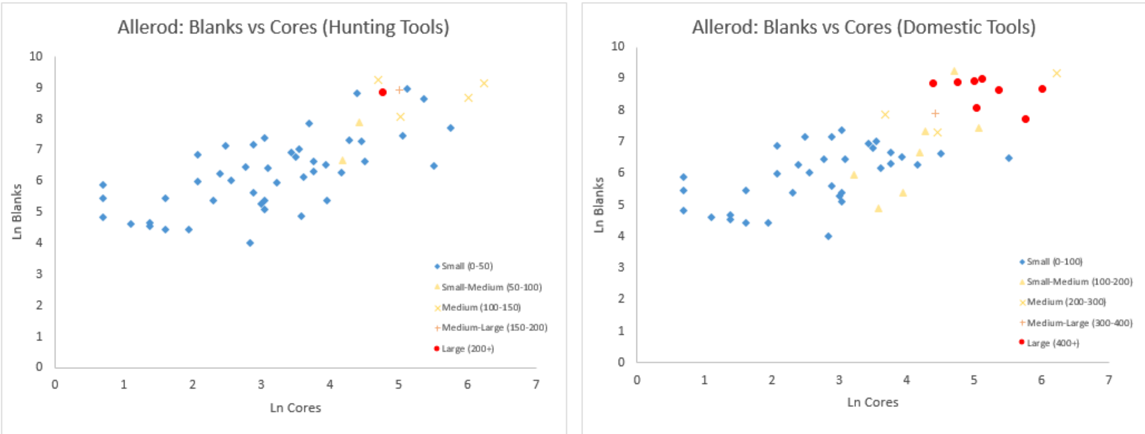
When comparing the results of the B/C from north and south it was found there is a statistically significantly larger mean B/C value in the southern PB assemblages than when compared with the north-western (p=0.001). This suggests populations during the PB in south Europe practised a significantly lower level of mobility and thus potentially were much more logistically mobile than in the northwest. There are no statistically significant differences between the northwest and south Allerød and YD values, although the YD has a notably lower mean value in the south dataset which might suggest an increase in mobility, potentially in a more residential system, which forms a level of agreement with the results of the B/T ratios.

The variance of the northwest YD dataset is distinctly higher than in the south, which might support the interpretation the northwest YD was more highly logistically organised. The south PB also has a distinctly higher variance, which again might support the interpretation of the south PB populations being more logistically organised.

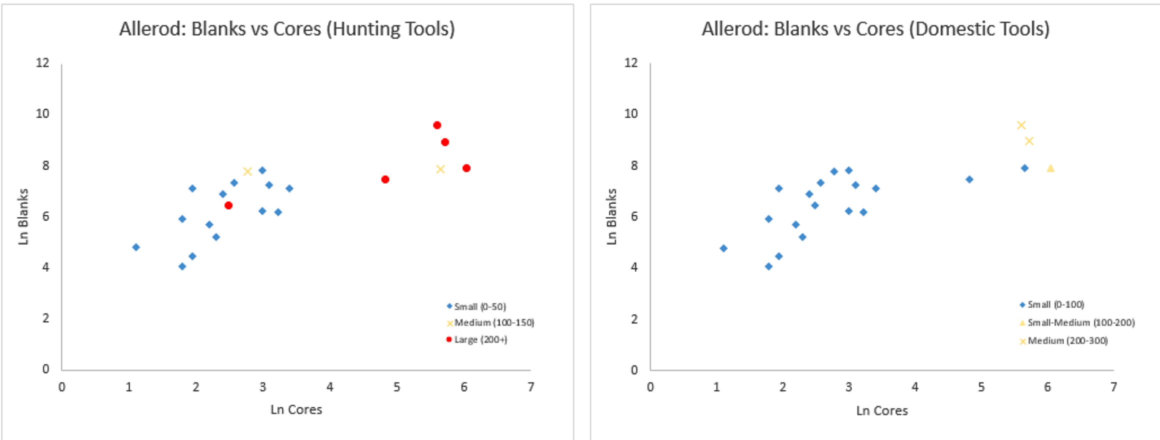
Numbers of Hunting and Domestic Tools

Figures 6.8 to 6.10 show, again, there is a trend of an increased importance of hunting tools in assemblages in the south Allerød and to a lesser degree the PB. The YD again appears to be similar, and suggests hunting may have been less important comparatively to the Allerød and PB in the south

Northwest

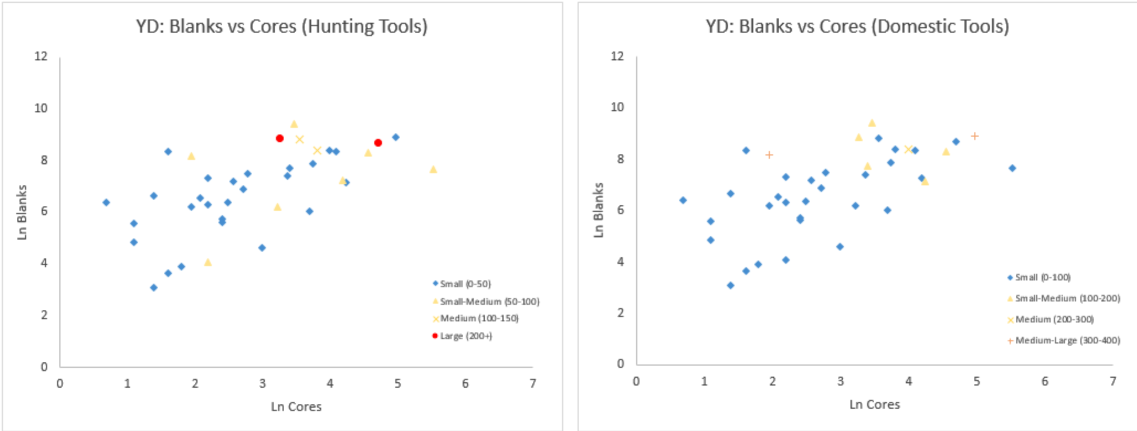


South

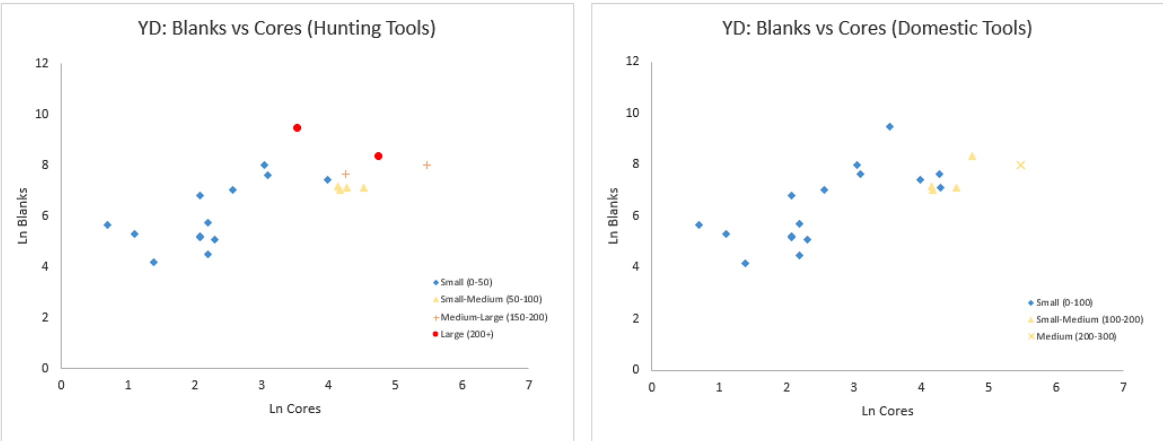


(Fig 6.8: Comparison of the numbers of hunting tools and domestic tools within assemblages between the N.W. and S. Allerød sample)

Northwest

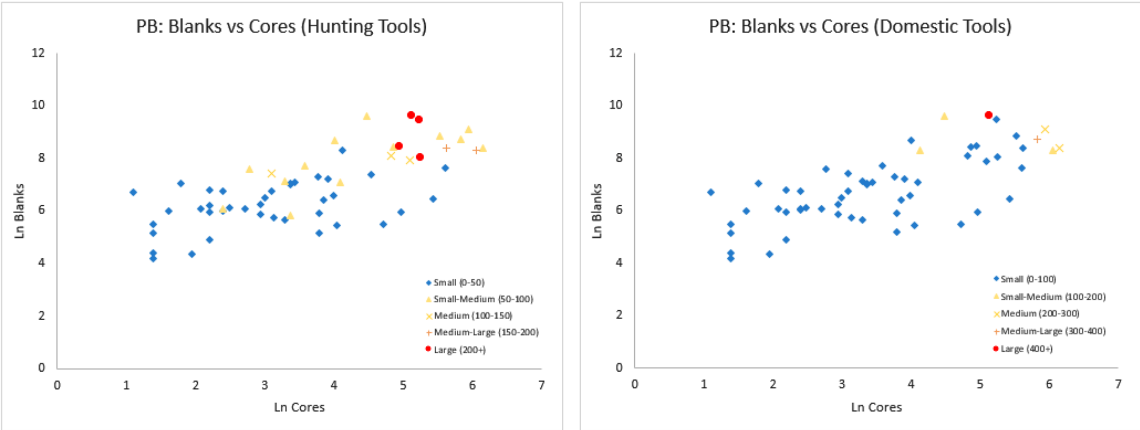


South

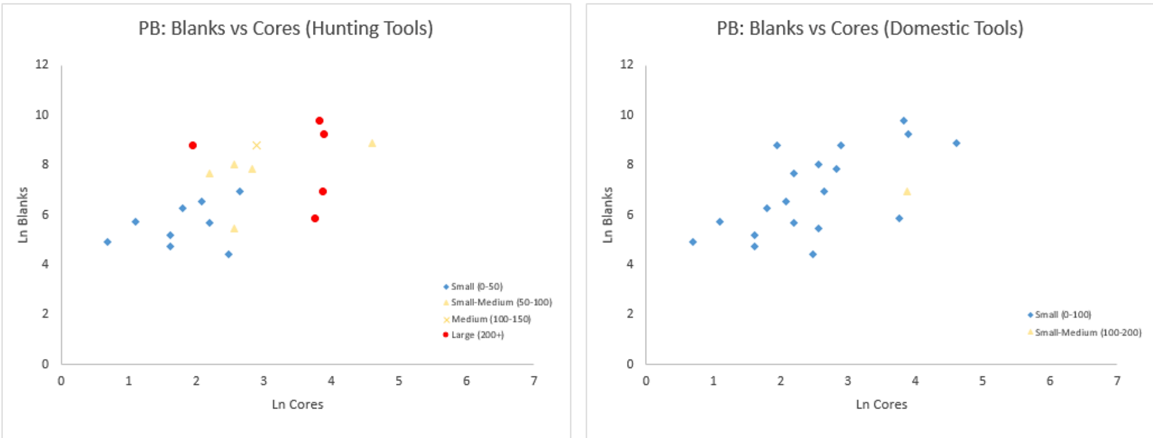


(Fig 6.9: Comparison of the numbers of hunting tools and domestic tools within assemblages between the N.W. and S. YD sample)

Northwest



South



(Fig 6.10: Comparison of the numbers of hunting tools and domestic tools within assemblages between the N.W. and S. PB sample)

6.2c - Analysis of Percentage of Retouched and Utilised Blanks

Below are the results of the percentage of URB in the total and tool assemblages (Tables 6.9 and 6.10), while the statistical analyses are presented in A3.51 and A3.52 in Appendix 3.

In Total Assemblage

N.W.	μ	n	σ	σ^2	S.	μ	n	σ	σ^2
Whole Dataset	2.939	180	3.794	14.393	Whole Dataset	0.704	57	1.401	1.964
Allerød	3.165	52	3.862	14.915	Allerød	0.588	20	0.700	0.490
YD	1.551	32	1.371	1.879	YD	1.416	20	1.575	2.482
PB	3.809	60	4.449	19.792	PB	0.364	15	0.889	0.789

(Table 6.9: Comparison of the northwest and south mean percentage of URB in the total assemblage results)

When comparing these results, a significant and distinctly lower mean percentage of URB in the total assemblage between the northwest Allerød and south Allerød (p=0.005), and northwest PB and south PB (p=<0.001) regions is apparent. This suggests populations in south Europe had a distinctly lower level of expediency in the Allerød and PB compared with their northwest counterparts and thereby indicating a higher level of residential mobility. However, the YD has very similar mean values, which suggest a similar level of mobility was employed in both regions (although the mean values in the northwest dataset is distinctly lower than the Allerød and PB).

In Tool Assemblage

N.W.	μ	n	σ	σ^2	S.	μ	n	σ	σ^2
Whole Dataset	23.964	193	18.479	341.484	Whole Dataset	8.699	80	7.396	54.695
Allerød	22.791	56	16.312	266.082	Allerød	7.378	26	6.028	36.331
YD	18.267	32	12.414	154.098	YD	12.676	24	8.888	79.001
PB	33.882	65	20.340	413.721	PB	7.070	24	6.949	48.288

(Table 6.10: Comparison of the northwest and south mean percentage of retouched and utilised blanks in the tool assemblage results)

The results of the comparison of the percentage URB in the tool assemblage are similar to the percentage in the total assemblage, with northwest Allerød region (p=0.001) and the northwest PB region (p=<0.0001) being significantly statistically higher than their southern counterparts. These lower mean percentages are especially pronounced in the south PB assemblages suggesting a distinctly different manufacturing strategy regarding the production of URB's, interpreted here as a shift to a much lower level of mobility related to a higher level of logistical mobility.

6.2d - Raw Material Procurement

In comparison to the northwest results the south assemblages, for each period, have distinctly lower percentages of local raw materials and thus also distinctly higher percentages of non-local raw materials (Table 6.11). This potentially indicates a higher level of residential mobility was practised in the south throughout all the periods, which agrees with the results of the URB.

N.W.	% Local	n	% Non-Local	n	**S.**	% Local	n	% Non-Local	n
Whole Dataset	82	98	18	22	Whole Dataset	51.163	22	48.837	21
Allerød	77	30	23	9	Allerød	40.000	6	60.000	9
YD	75	9	25	3	YD	44.444	4	55.556	5
PB	88	37	12	5	PB	63.158	12	36.842	7

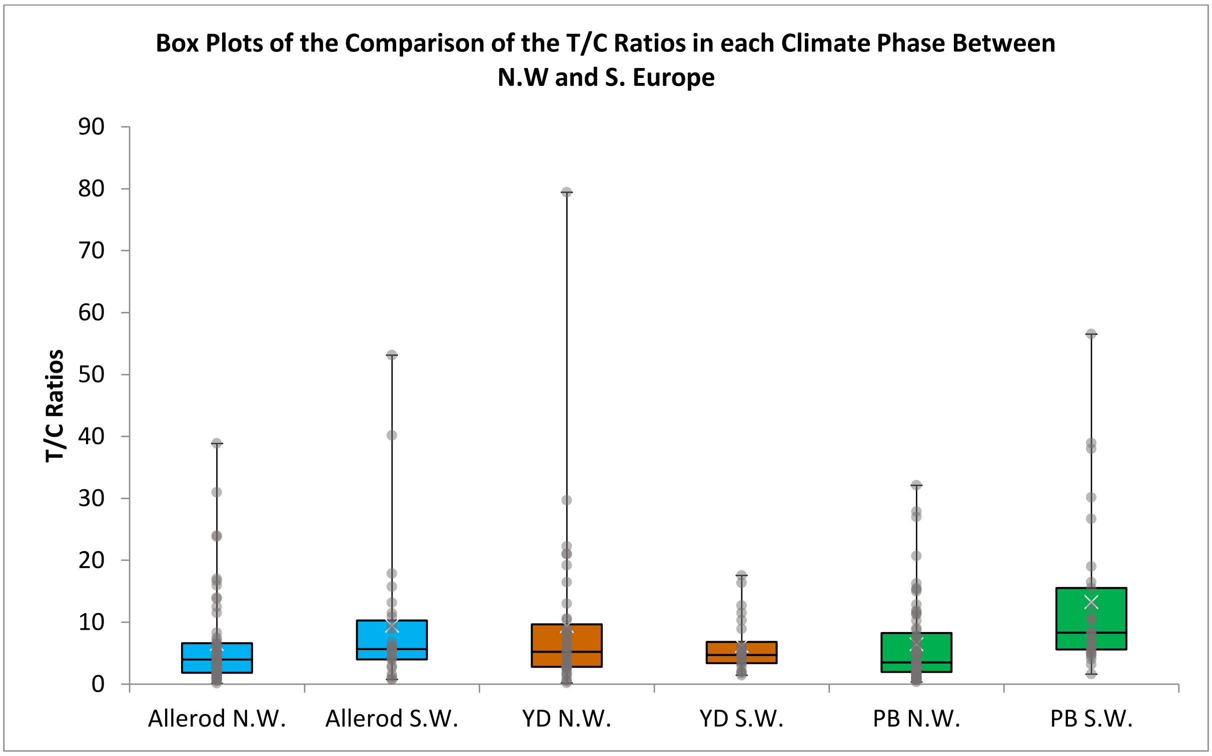
(Table 6.11: Comparison of the northwest and south raw material provenance results)

6.2e – Analysis of the Tool to Core Ratio

The results of the comparison of the T/C ratios are presented in Table 6.12 and Fig 6.11, and the statistical analysis presented in A3.53 in Appendix 3.

N.W.	μ	n	σ	$σ^2$	S.	μ	n	σ	$σ^2$
Whole Dataset	6.805	209	8.910	79.384	Whole Dataset	9.856	80	10.881	118.391
Allerød	6.494	58	7.714	59.505	Allerød	9.432	27	11.710	137.1130
YD	9.400	39	13.446	180.784	YD	6.200	24	4.442	19.735
PB	6.426	63	6.892	47.498	PB	13.276	29	12.913	166.752

(Table 6.12: Comparison of the northwest and south mean T/C ratio assemblage results)



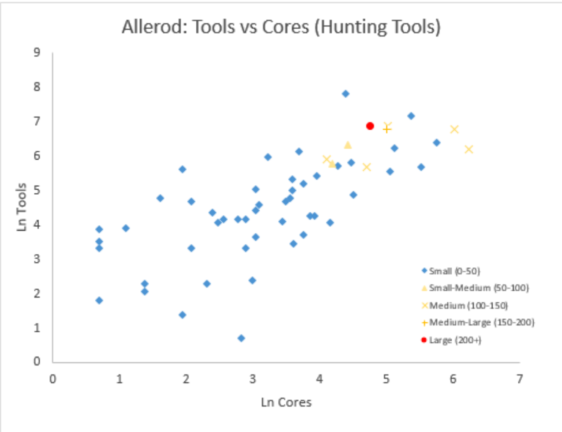
(Fig 6.11: Box plots of the comparisons of the T/C ratios for each climatic phase between the N.W. and S. datasets)

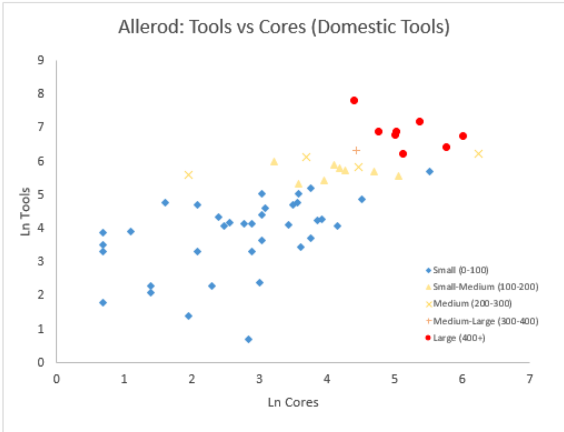
When comparing these results with the northwest data, the south PB has a significantly higher mean value than the northwest PB (p=0.0002), which may indicate a significant difference in tool manufacturing strategies with a much more economical strategy employed in the south region. However, again this might be a consequence of a higher number of logistical sites with many tools and few cores. In general, it appears there is a reversal of the trend seen in the south data with a higher mean value during the YD compared with the Allerød and PB, suggesting a more economical use of raw materials in the northwest YD populations and a less economical use of raw materials in the northwest Allerød and PB. This would translate to a more logistical organisation during the YD and a more residential organisation during the interstadial phases. There are no statistically significant differences between the Allerød and YD between the regions.

<u>Numbers of Hunting and Domestic Tools</u>

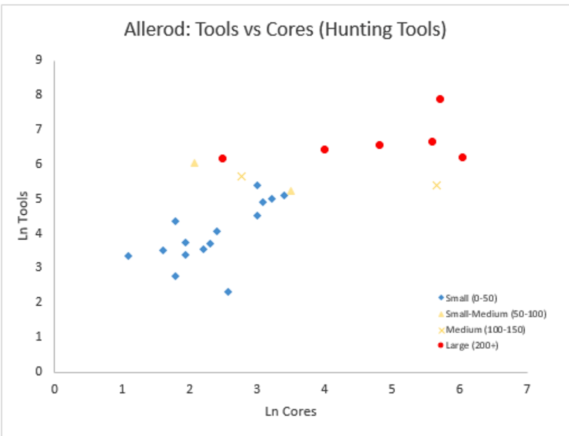
Once more Figures 6.12 to 6.14 show the increased importance of hunting tools within assemblages from the south particularly during the Allerød, and to a lesser extent the PB, while the northwest and south YD are similar, again showing a greater importance on hunting tools. However, the south YD sites seem to show a lesser reliance on hunting tools when compared with the Allerød and PB.

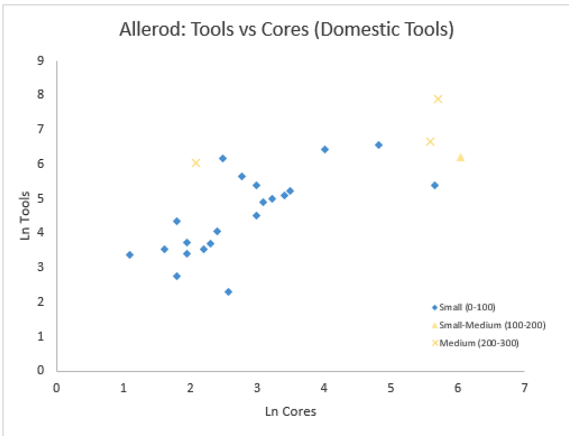
Northwest





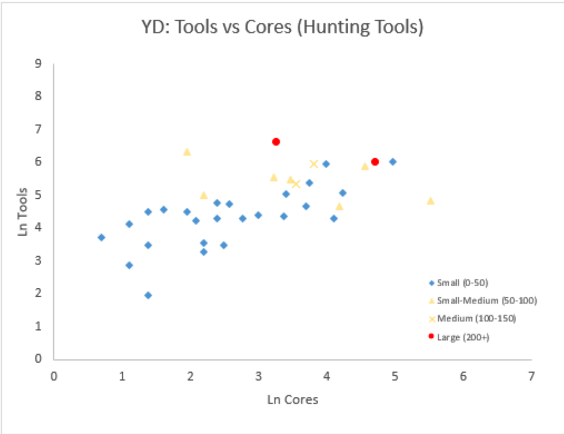
South

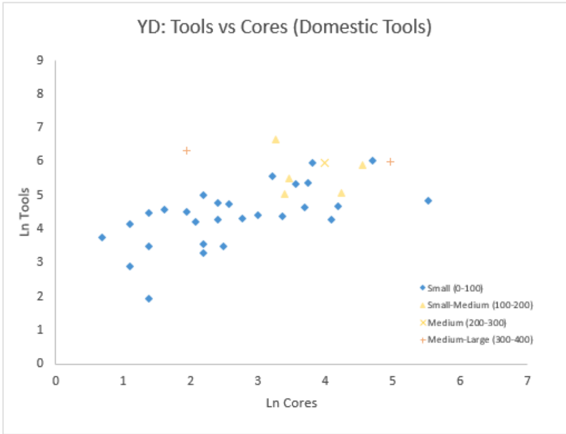




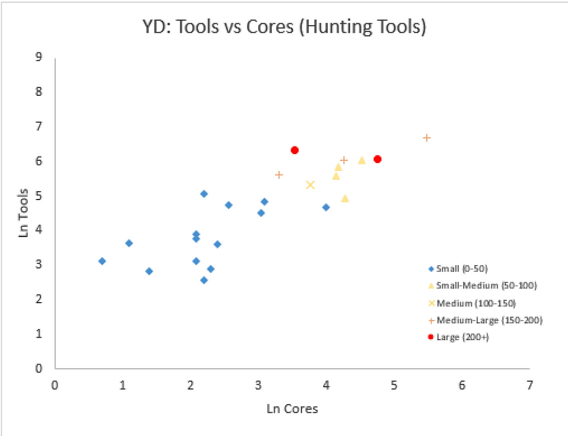
(Fig 6.12: Comparison of the numbers of hunting tools and domestic tools within assemblages between the N.W. and S. Allerød sample)

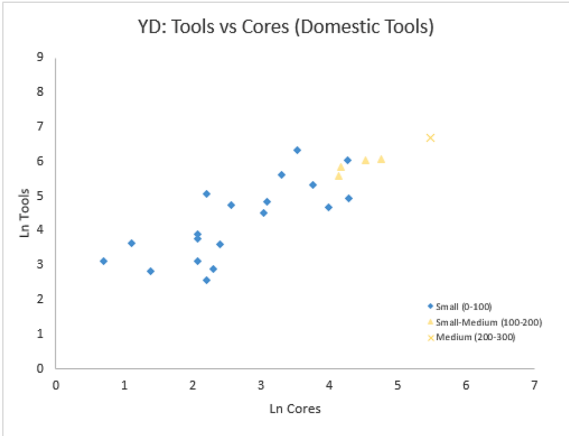
Northwest





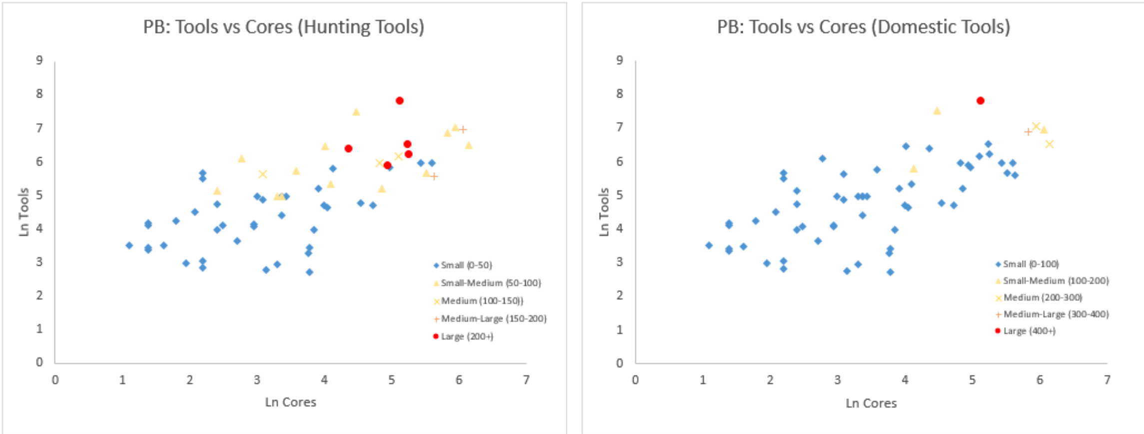
South



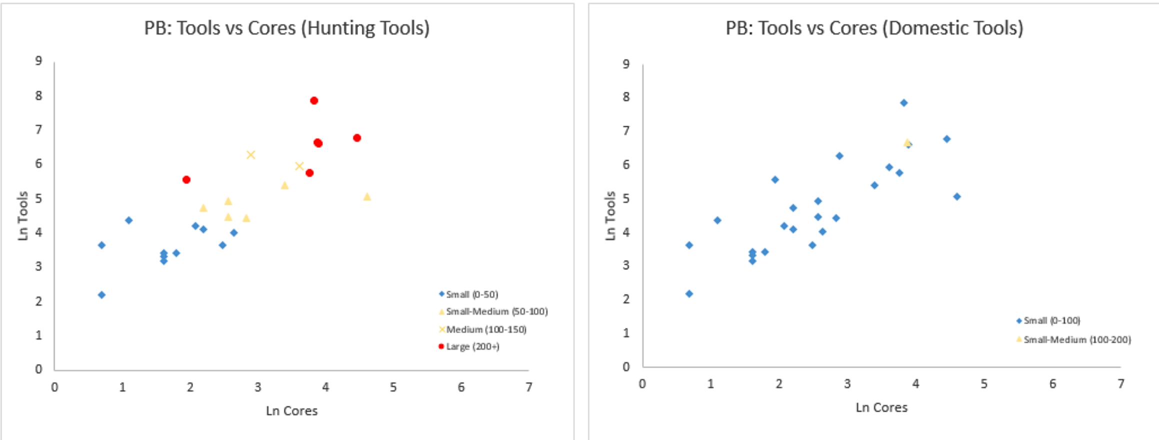


(Fig 6.13: Comparison of the numbers of hunting tools and domestic tools within assemblages between the N.W. and S. YD sample)

Northwest



South



(Fig 6.14: Comparison of the numbers of hunting tools and domestic tools within assemblages between the N.W. and S. PB sample)

6.3 - Summary of Comparisons

	Allerød	YD	PB
Richness	Slightly lower	Much higher	(Slightly lower)
Evenness	(Notably lower)	Much higher	(Notably lower)
% Microliths	(Higher)	(Slightly higher)	Much higher
Density (m^2)	Much higher	(Much higher)	Much higher
Number of artefacts	Higher (near statistical significance)	(Lower)	(Higher)
B/T ratio	(Notably higher)	(Notably lower)	(Higher)
B/C ratio	(Notably higher)	(Notably lower)	Much higher
T/C ratio	(Notably higher)	(Notably lower)	Much higher
% URB	Much lower	(Lower)	Much lower
Raw material provenance	Notably more non-local	Notably more non-local	Notably more non-local

(Table 6.13: How the S. analysis results compare to the N.W. [brackets denote statistically non-significant results])

Table 6.13 summarises the comparison of the south dataset to the northwest dataset. It appears the south assemblages have a lower richness and evenness during the Allerød and PB and a significantly much higher richness and evenness during the YD. This suggests populations in the south were practising a more logistical strategy during the interstadial phases, and a more residential strategy during the YD stadial, compared with populations in the northwest.

The number of microliths in the south are higher in every period, especially so during the PB. However, the trend of steadily increasing numbers of microliths from the Allerød to YD, and an apparent explosion of microlithic technology in the PB is seen in both regions, but notably more pronounced in the south samples. If microliths are agreed to be a suitable indicator of complexity, this suggests populations were more complex in the south, and indicating more logistically organised populations.

The B/T and B/C ratios appear to be higher in the interstadial phases (especially in the PB) and lower in the YD stadial, indicating populations in the south were more logistically organised in the Allerød and particularly the PB, and more residentially organised during the YD. This agrees with the results of the richness and evenness analysis.

The T/C ratio follows the same pattern as the B/T and B/C ratios, but this might suggest populations were utilising raw materials more economically in the Allerød and PB, and less so in the YD in the south. This indicates a more residential mobility system in the interstadial periods and a more logistically mobile system in the YD in this region.

The URB analysis shows there was a uniformly lower percentage of retouched and utilised blanks in the south, which is notably much lower in the interstadial phases. This suggests populations in the south were generally more residentially organised with less use of unmodified blanks in a more formalised tool manufacturing strategy. A greater level of residential mobility in the south is further supported by the raw material data, which suggest the predominant sources of raw materials were from non-local resources.

On the weight of evidence, it can be concluded populations in the south were generally more logistically organised during the Allerød and PB and more residentially organised during the YD. However, there is evidence from the URB and raw material data, to support there is the potential that populations were more residentially organised throughout all the periods, although these analyses might be flawed through unreliable/insufficient reporting within the literature. The T/C ratio results seem to be an anomaly, much as in the individual region analysis and may prove unsuitable as an indicator for economical use of raw materials. Despite these inconsistencies, it is clear populations during the YD seem to be more residentially mobile than their northwest European counterparts, while the interstadials might be less certain.

6.4 - Site Type Analysis

Comparison of Northwest and South Data

The following analysis will test to see if there are any notable differences in the B/T, B/C, and T/C ratios from the base camps and special task camps assemblages between the northwest and south regions to ascertain whether there was a different response to the YD at different latitudes.

Numbers of Camp Types

Tables 6.14 and 6.15 show the numbers of designated base camps and special task camps respectively, that were assigned by the methodology set out in Chapter 4. It is clear, proportionally, the interstadial phases in the south have notably lower numbers of base camps and higher numbers of special task camp, particularly in the case of the PB. This would suggest populations were more logistically mobile during the Allerød and PB. In contrast, the south YD has notably proportionally higher numbers of base camps compared with special task camps, which are spread equally. This is more indicative of a more residential strategy.

	No. N.W. Base Camps	No. S. Base Camps	% N.W Base Camps	% S. Base Camps
Total	90	36	47.12	33.33
Allerød	45	13	58.44	33.33
YD	13	16	28.89	48.48
PB	32	17	46.38	19.44

(Table 6.14: Number and percentage of recognised base camps in the N.W. and S. datasets)

	No. N.W. Special Task	No. S. Special Task	% N.W Special Task	% S. Special Task
Total	101	72	52.88	66.67
Allerød	32	26	41.46	66.67
YD	32	17	71.11	51.52
PB	37	29	53.62	80.56

(Tables 6.15: Number and percentage of recognised special task camps in the N.W. and S. datasets)

6.4a - Comparison of Indicators in Base Camps and Special Task Camps

The following sets of analyses (shown in Tables 6.16-6.21 with statistical analysis presented in A3.54-A3.59 in Appendix 3) show the comparisons between the northwest and south mean ratio values in the designated base camps and special task camps. It might be expected there should be a notable difference in the base camp component from north to south if there is a difference in mobility strategies employed by human populations. However, this appears not to be the case. However, there is very little evidence for statistically significant differences between north and south B/T, B/C, and T/C ratios between base camps and special task camps were found, with the only exceptions possibly being the B/T ratios of the PB base camps (p=0.025) where the southern sites had significantly lower values. However, this result is highly unreliable due to the very small sample size. Another possible candidate is the T/C ratios in the PB special task camps (p=0.002) where the southern sites have a significantly higher T/C ratio (p=0.002), but again the sample size of this group is very low and is unreliable. The only reliable candidate for a statistically significant difference between north and south regions, with a more robust sample size, is from the B/C ratios from the PB special task camps, which are distinctly higher in the southern sites (p=0.001), suggesting these site types where more expedient in nature. This might indicate special task camps in a more logistically mobile system.

Allerød

	N.W. Allerød Base Camps				S. Allerød Base Camps			
Indicator	n	μ	σ	σ^2	n	μ	σ	σ^2
B/T Ratio	43	8.356	5.897	34.778	9	6.033	3.022	9.133
B/C Ratio	38	34.997	36.163	1307.758	9	40.409	22.325	498.423
T/C Ratio	40	6.123	6.692	5.727	10	7.279	4.445	19.758

(Table 6.16: Mean B/T, B/C, and T/C ratios for the N.W. and S. assemblages classed as base camps for the Allerød)

	N.W. Allerød Special Task Camps				S. Allerød Special Task Camps			
Indicator	n	μ	σ	σ^2	n	μ	σ	σ^2
B/T Ratio	29	7.303	8.052	64.832	21	15.498	32.061	1027.886
B/C Ratio	19	53.036	41.378	1712.147	15	66.674	55.122	3038.401
T/C Ratio	20	10.670	12.288	150.988	18	11.260	14.811	219.357

(Table 6.17: Mean B/T, B/C, and T/C ratios for the N.W. and S. assemblages classed as special task camps for the Allerød)

Younger Dryas

	N.W. YD Base Camps				S. YD Base Camps			
Indicator	n	μ	σ	σ^2	n	μ	σ	σ^2
B/T Ratio	13	14.253	10.402	108.251	14	9.388	6.521	42.522
B/C Ratio	13	93.991	83.567	6978.391	13	50.190	44.958	2021.196
T/C Ratio	13	6.967	5.468	29.901	14	7.647	7.440	55.347

(Table 6.18: Mean B/T, B/C, and T/C ratios for the N.W. and S. assemblages classed as base camps for the YD)

	N.W. YD Special Task Camps				S. YD Special Task Camps			
Indicator	n	μ	σ	σ^2	n	μ	σ	σ^2
B/T Ratio	30	14.463	14.737	217.180	12	14.563	10.290	105.892
B/C Ratio	30	108.791	179.179	32105.140	9	139.111	201.621	40651.201
T/C Ratio	31	10.226	14.734	217.096	11	8.579	7.767	60.325

(Table 6.19: Mean B/T, B/C, and T/C ratios for the N.W. and S. assemblages classed as special task camps for the YD)

Preboreal

	N.W. PB Base Camps				S. PB Base Camps			
Indicator	n	µ	σ	σ^2	n	µ	σ	σ^2
B/T Ratio	32	9.457	10.049	100.977	3	3.278	0.979	0.958
B/C Ratio	29	44.668	52.195	2724.358	3	32.572	31.693	1004.416
T/C Ratio	29	6.340	6.008	36.001	5	7.693	6.425	41.285

(Table 6.20: Mean B/T, B/C, and T/C ratios for the N.W. and S. assemblages classed as base camps for the PB)

	N.W. PB Special Task Camps				S. PB Special Task Camps			
Indicator	n	µ	σ	σ^2	n	µ	σ	σ^2
B/T Ratio	36	10.463	7.910	62.582	18	13.949	11.557	133.563
B/C Ratio	35	48.468	51.243	2625.823	17	181.991	230.953	53339.232
T/C Ratio	36	6.560	7.977	63.639	19	14.457	14.050	197.402

(Table 6.21: Mean B/T, B/C, and T/C ratios for the N.W. and S. assemblages classed as special task camps for the PB)

6.4b – Summary of Site Type Analysis

When looking at the designated site types, it is notable there are clear differences in the numbers of base camps and special task camps during each phase in the northwest and south. There are distinctly more base camps and fewer special task camps in the south during the YD and distinctly fewer base camps and a greater number of special task camps during the Allerød and especially the PB. This strongly suggests populations in the south were distinctly more residentially mobile during the YD and more logistically mobile during the Allerød and particularly the PB.

However, due to the smaller sample sizes of the southern European data, caution must be observed whilst interpreting these results. It appears there is no obvious difference between the northwest and south base camp B/T, B/C, and T/C values between any of the periods (although the sample size is particularly low in this dataset). Within the special task camps, there is significantly larger mean value in the PB for the B/C ratios in the south dataset, suggesting populations during this period in the south have a much more logistical signal in their special task camps. This may also be true of the south YD, which has a notably larger mean B/C ratio, although with no statistical significance. During this period there is also a notably lower mean B/C ratio in the designated base camps, which might be expected in a base camp in a more residential strategy, with a lower level of expediency, although again there is no statistical difference between these values. Another notable difference is that there is no statistically significant difference seen in the mean Allerød B/T ratio in the special task camps, in which the south value is notably higher. This might suggest a more logistical system was employed within special task camps in the south during the Allerød. Overall very little can be interpreted from the ratio values in these results, apart from there appearing to be no statistical differences between the base camps and special task camps between any of the periods, with the exception of the B/C ratio of the PB.

6.4 - Conclusion

Overall, there is quite strong evidence suggesting populations during the Allerød and PB phases were more logistically mobile in the south than in the northwest, and populations during the YD phase were more residentially mobile in the south than in the northwest.

If we accept Binford's (1980) expectation that logistical mobility would be a predicted trait of humans living in cold climates, then the results of this analysis support this in the northwest, where YD populations appear to be significantly more logistically mobile in harsher conditions, where there is evidence of permafrost for much of the year, and periods of deep snow cover. In contrast, the south did not have such harsh conditions during the YD, although the vegetation response was similar (i.e. an opening of the landscape), average temperatures were not cold enough to facilitate the harsh conditions seen in the northwest, most notably permafrost and deep snow cover. This appears to have had a significantly different effect on the mobility strategies of southern Europeans, who appear to be notably more residentially mobile than their northwest counterparts during the YD.

However, the interstadial phases in the south seem to be notably more logistical in nature, which suggests a different mobility response system was already in place in the south (perhaps related more to cultural and traditional factors rather than climate and environment) as one would expect, the distinctly more comfortable conditions of the Allerød and PB in both the northwest and south would facilitate the same mobility response if mobility is directly related to climate change. Perhaps the exact nature of the human response to climate change are routed in local/regional traditions and cultural heritage, rather than there being an optimal strategy for any one type of climate change that is universally followed.

Chapter 7: Discussion

7.1 – Introduction

This study has (i) discussed the environmental changes observed from the Allerød, YD, and PB climatic phases in northwest and south Europe, (ii) explored how, theoretically, hunter-gatherers and their tool assemblages should respond to these environmental changes, and (iii) collected and analysed an extensive lithic tool assemblage dataset from northwest Europe and a comparative dataset from south Europe. It has been concluded there were significant climatic changes, from a warmer climate and more closed environments during the Allerød and PB interstadials to much colder and open environments during the YD in northwest Europe, while there was a much more muted environmental response in south Europe. The theoretical models, heavily influenced by Binford's studies (e.g., Binford, 1980) as discussed in Chapter 2, predicted there should be a decrease in mobility during colder and harsher environments, represented by an increase in logistically mobile behaviour, in contrast to an increase in mobility during warmer, more plentiful, environments represented by more residentially mobile behaviour. The results of the analysis, presented in Chapters 4-6, found there was evidence of a statistically significant decrease in mobility, during the colder conditions of YD in northwest Europe, to a more logistically mobile strategy, while populations during the Allerød and PB Interstadials were practising a more mobile, more residential mobility strategy. However, in south Europe, no evidence was found for a statistically significant shift in mobility from the Allerød to the YD (although there is possible evidence of a slight shift to a more mobile strategy into the YD), but there is strong statistically significant evidence suggesting there was a major shift to a more logistical strategy at the beginning of the Holocene, during the PB. Also, there is evidence suggesting the southern populations appear to be generally more residentially mobile throughout the Pleistocene/Holocene Transition, compared with the northwest populations.

Here, the results of the lithic assemblage composition analysis will be discussed to determine firstly, if the theoretical models provide a suitable framework to interpret mobility changes in response to major climatic events, secondly, if the analysis of lithic assemblages are sensitive enough to observe these changes, and thirdly, provide an interpretation of how hunter-gatherer populations reacted and adapted to the YD. Finally, the results and interpretations will be compared with results from similar, global, studies to determine if, or how, the western European hunter-gatherer population behaviours differ from the global human response to the YD event.

7.2 - Interpretation of the Results

The results of the northwest European analysis seem to support the theoretical predictions set out in Chapter 2, with a general trend of more logistically mobile indicators during the YD Stadial and more residentially mobile indicators during the Allerød and PB Interstadials. This would suggest hunter-gatherers were less mobile and more specialised during the colder and harsher conditions of the YD, while becoming more mobile and more generalised during the warmer Allerød and PB, much as Binford (1980) predicts. However, the PB appears to be distinctly different from the Allerød, in that the indicators generally suggest populations were less mobile during this period. One might expect the two warm Interstadial phases would elicit similar responses in mobility by human populations, but this does not seem to be the case. However, it has been shown the PB climate and environment was much more unstable than the Allerød (See Chapter 1), with several different phases of colder and drier conditions (most notably the Preboreal Oscillation or PBO), which may have had an adverse effect on human populations when compared with relatively continuous, warm, conditions during the Allerød. The higher level of PB logistical mobility compared with the Allerød, may be an adaptation to the uncertainty caused by these more unstable conditions.

In contrast, the south European analysis suggests a more muted response to the YD, with the B/T, B/C, and T/C ratios indicating little statistically significant differences between periods, unlike the northwest data. However, it appears from the richness, B/T ratios, and site type analysis, there is a possible slight reversal from that seen in the northwest dataset. The YD assemblages possibly indicate that populations were practising a slightly more residentially mobile strategy, while they appear to be practising a more logistical strategy during the Allerød and especially in the PB, where there is a pronounced logistically mobile signal. However, this slight increase in residential mobility is not statistically significant, and it could equally be said there is little difference within the tool indicators between the Allerød and YD, a result which supports much of the current research carried out in south Europe, most notably northern Spain, which will be discussed later. Either way, this result seems to strongly indicate there was a distinctly different response in south Europe to the more direct climatic and environmental effect of the YD on northwest European populations, which one might expect. In turn, this may indicate the models for tool assemblage composition changes in response to climate outlined in this study may be suitable for observing changes in hunter-gatherer mobility/behaviour.

When comparing the two datasets, northwest populations seem to be generally less mobile, while southern populations generally seem to be more mobile. This seems to correlate with the climatic and environmental conditions in each region. Jones (2016) agrees with this finding, noting the more muted response to the YD in south Europe facilitated a more residentially mobile strategy throughout the Late Glacial and Early Holocene, although she highlights there might be a slight shift to a more logistical strategy during the YD, where there was a reported, slight, restriction in mammalian diversity in some regions, which may have forced populations to a more specialised strategy. This does not agree with the results here, which suggest, if anything, there was a shift to a slightly more residential strategy. However, in the northwest the return of large herds of migratory reindeer and horse, unavailable to the previous Allerød populations, and the disappearance of more stationary species such as red deer (Eriksen, 1996; Gamble et al., 2004: Bignon and Eisenmann, 2002), in a more open landscape during the YD, may have forced populations to practise a higher level of logistical mobility in order to exploit this species in a period of low bioavailability. Drucker et al. (2016) also report a possible reliance on freshwater sources during YD at the site of Rhünda in northern Germany, with the seasonal exploitation of reindeer. This again appears to be more in line with less mobile populations that practised a more logistically mobile subsistence strategy during the YD.

A number of indicators appear to be significantly different between climatic periods, but seem not to be related directly to the climate change of the YD, most notably the values of evenness, and the percentage of microliths. It would be expected, if a shift was a result of changes from the warmer Allerød to the colder YD, there should be a reverse shift from the colder YD to the warmer PB. This would suggest, if these differences represent changes in mobility/behaviour, they are caused by other factors, possibly related to changes in population demographics, changes in social interactions, or simply to changes in technology that are not related to climate and the environment.

Another interesting result is there appears not to be a statistically significant change in the numbers and percentages of tools, blanks, and total numbers of artefacts with altitude and excavation/"site size" in either the northwest or southern datasets. This is more surprising in the southern dataset as there are a large range of altitudes from ca. 50-2000 masl in northern Spain, the Pyrenees, the Alps, and pre-Alps. It is widely assumed early prehistoric special-task site types are located at higher altitudes, which have unique functions and toolkits (see discussions by: Aldenderfer, 2006; Adler et al., 2006; Clarke and Kurishima, 1979; Walsh, 2005; Walsh et al. 2006), although there is rare evidence for prehistoric high-altitude residential camps in North America and the Tibetan Plateaux (see Morgan et al., 2012; Brantingham et al., 2003). This conclusion seems to be supported in the site type analysis where there appears to be no significant difference between the tool, core, and blank ratios in the designated base camps and designated special task camps. This contradicts the general belief that higher altitude sites, or sites of smaller size, are usually specialist function sites, or alternatively, that numbers of tools, blanks, and artefacts are not sensitive enough to observe these changes.

The differences in tool assemblage composition, and thereby mobility, between the northwest and south European datasets are assumed here to be related to the differing, generalised, climatic and environmental changes in each region, but what are the exact differences between the northwest and south European climatic and environmental changes during this period, and are they substantial enough to justify this conclusion?

7.3 - Summary of the Northwest and South European Climatic and Environmental Evidence

The climatic evidence suggests there was a similar dramatic effect on the vegetation with the onset of the YD in both the northwest and south regions, with a distinct lowering of temperature (although the drop in temperature was notably more subdued in the south) and an opening of the landscape during the YD, followed by a rapid amelioration in temperatures and the expansion of forest with the onset of the PB. However, this effect seems to be more varied from region to region in the south, which has a much more varied topography than the northwest, and there appears to be many areas of refugia for warmer climate vegetation in the mountains and on the Mediterranean coast during the YD. In comparison, the environmental reaction in the northwest appears to be relatively uniform, most likely due to the comparative lack of geographical variation (where the changes in altitude of landforms are significantly less pronounced). However, areas of environmental refugia have been theorised in this region too. There is also evidence in the south of the halting of the warming process during both the Allerød and PB, with arid cooling periods evident during the mid-point and end of the Allerød and a period of aridity during the PBO, similar to that seen in the northwest European data. However, the YD appears to be more uniform between north and south regions, with a cold and dry initial phase and a warmer, but still dry, later phase apparent in both the northwest and south.

In the northwest, the PB Interstadial is notably different from the Allerød Interstadial. One might expect human populations in warmer periods would have similar mobility strategies, but this appears not to be the case. PB populations, although distinctly more residentially mobile during the preceding YD, were more logistically mobile than the Allerød and in many ways similar to the YD in this regard. Straus (2013) states the northern European hunter-gatherers practised a "Palaeolithic" settlement-subsistence strategy based on high mobility hunting of reindeer over large territories during the YD and this 'lifeway' then crashed with the onset of the warmer Holocene conditions. However, this was not found in results of this research, which suggests there was in fact a shift to a less mobile strategy during the YD in northwest Europe, compared with the Allerød, and there appears to be little evidence for a 'crash in lifeways' into the Holocene, as there are greater similarities between the YD and the PB lithic assemblage compositions than between the Allerød and the YD. It is vital to note that the shift into the Holocene in northwest Europe should also not be simply seen as a dramatic, rapid, return to warm and stable conditions. On the contrary, there is strong evidence, outlined in Chapter 1, that this period was erratic, with warm wet phases interrupted by brief cool and dry episodes. It is this variability, in wet and dry conditions, during the PB in northwest Europe that is believed here to be the cause of the changes in patterns of mobility observed.

Straus (2013), states, in contrast to the northwest, the south European populations practised a broad-spectrum subsistence strategy since the Allerød, which continues into the YD, where there appears to be little change in human behaviour despite the opening of the landscape, and that there was no ‘crash in lifeways’ evident with the onset of the Holocene. From this he concludes “environmental determinism must be tempered with the realisation that regionally deep-rooted foraging cultures had a considerable inertia and resilience with an ability to adapt to a wide range of climatic variations” (Straus, 2013: 250). This continuation of an earlier broad-spectrum economy in the south into the YD, is somewhat supported by this research, where there appears to be a much more subdued response in the toolkits in this region. However, there is a possible slight change to a higher level of mobility during the YD that might signal a change in behaviour relating to different climatic and environmental conditions, although this shift is not statistically significant, and thus may not represent a change at all. Interestingly, the finding by Straus (2013), that there was no evident ‘crash in lifeways’ in the south with the onset of the Holocene appears not to be reflected in the results my analysis. There is a statistically significant shift to a more logistical strategy during the PB, in which populations are much less mobile (according to the toolkit indicators), and this would suggest there was in fact some kind of major change in lifeways, at least in terms of mobility, during this phase.

The general similarities in the lowering temperatures (although more subdued) and the opening of the landscape between the two regions during the YD, followed by a rapid increase in temperature and growth of forests into the PB, suggests a similar human mobility response would be seen in south Europe as in northwest Europe. Conversely, there appears to be an opposite reaction, with more logistically mobile populations in the northwest during the YD and possibly more residentially mobile populations in the south during the YD, and more residentially mobile populations in the northwest during the Allerød and PB interstadials, and more logistically mobile populations in the south during the Allerød and PB interstadials. This appears to be an unexpected result and casts doubt on the suitability of the lithic assemblage indicators for mobility tested in this study. However, this line of evidence only takes into account the changes in temperature and vegetation, but not the differences in animal populations between each region. A significantly different faunal species composition would presumably have a much larger effect on hunter-gatherer mobility. The next section will discuss the differences between the northwest and south European faunal evidence.

7.4 - Hunted Faunal Species and their Possible Effect on Mobility in Northwest and South Europe

As we have seen, the environmental differences, in terms of vegetation response, are remarkably similar between the northwest and the south regions from the Allerød, to the YD, and into the PB. However, the exact environmental responses seem to be more variable from region to region within the south, and the temperatures were distinctly higher in this region than the northwest. The crucial question to ask here is; how did animal species react to these climatic and environmental changes in both regions, and more importantly, how did human populations exploit them?

Northwest Europe

In Europe, the warming during the Allerød has been associated with the beginnings of a broad-spectrum economy in mid-to-high latitude regions, evident from Binford's (1968) study into human diet diversification, and in later studies in southern France such as by Jones, (2009) and Rillardon and Brugal, (2014), suggesting this may have been a Europe-wide phenomenon. In the northwest, this phase saw the replacement of large herds of migrating reindeer by smaller groups of sedentary red deer and the growth of light forest from the previous steppe-tundra (Drucker et al., 2016). This is thought to have led to human populations broadening their diet and exploiting their environment over a smaller range (e.g. Aura et al., 1998; Debout et al., 2012). In contrast, effects of the YD were far more pronounced in the higher latitudes of France, Benelux, and Germany regions, where periglacial conditions, including permafrost re-expansion, induced the return of reindeer herds in steppe-tundra landscapes (e.g. Drucker et al., 2016). Reindeer seem to significantly contribute to the subsistence of hunter-gatherers in northern Germany and Belgium, in southern England, and potentially in the Dry North Sea (Doggerland). Also, fishhooks from northeast Germany, directly dated to the YD, suggest fish were also exploited (Drucker et al., 2016).

However, the Drucker et al. (2016) study into the isotopic analysis of the 'human of Rhünda' found reindeer represented only a small part of their diet (ca. 20% of protein), which is consistent with seasonal exploitation of this species, while it was freshwater resources that were the main protein source of the Rhünda individual. Drucker et al. (2016) speculate, in the northern lowlands of Germany, aquatic resources were used as an alternative during the YD stadial, when the amounts of available ungulates and plant biomass were relatively low. This suggests hunter-gatherers at this site during the YD were not highly mobile, rather located near to fresh water sources, exploiting reindeer seasonally when they entered their territory. This supports the results of this study which predicts YD populations practised a more logistical strategy.

There tends to be a greater focus on reindeer in studies belonging to this period, most likely due to the large body of literature relating to reindeer studies from southern France and Spain. However, it is important to note that wild horse (Equus ferus) would have also been a major component of European hunter-gatherers diet during the YD, particularly in north-western Europe. This species is known to have played an important subsistence role in the Late Pleistocene, and especially at the end of the Late Glacial, and was particularly well adapted to cold and arid steppe environments (Sommer et al., 2011). In the U.K. during the cool climate of the Creswellian (dating to the Bølling Interstadial), wild horse was dominantly represented in faunal assemblages (Barton, 1999) and several sites dating to the YD in northwest Europe have also yielded strong evidence for specialised horse hunting sites. These include Three Ways Wharf, Uxbridge, in southern England, Flixton 2, Yorkshire, northern England, and Belloy-sur-Somme, northern France (Lewis and Rackham, 2011). Although this species is now extinct, behavioural studies of semi-feral horses in Mongolia suggest that wild horse lived in small groups and were highly mobile, constantly moving around the landscape, and only becoming more stationary when foals were present during spring and early summer (Barton, 1999). This suggests that, like reindeer, wild horse posed a very different problem to that of warmer climate species such as red deer, and different hunting strategies would have to have been employed to successfully exploit them.

With the onset of the PB there was a dramatic increase in the number and diversity of warm climate adapted animals with the return of red deer and the inclusion of new species such as wild boar, roe deer, and elk, along with numerous small mammals, birds, and fish, and evidence for domestic dog (Clark, 1954; Wymer, 1962; Street, 1991). This would have likely enabled a more broad-spectrum economy (which started in the previous Allerød Interstadial), and thus a shift to a potentially more residential mobility strategy by hunter-gatherer populations in order to best exploit these more plentiful resources as they became available throughout the year, rather than a settlement strategy relying on base camp location near to key resources and the specialised targeting of more secondary resources that is predicted in a more logistical strategy.

Due to poor preservation of organic materials over much of the northwest region, the information on hunter-gatherer faunal exploitation is much less developed when compared with the extensive research carried out in the south of Europe. However, it seems fair to conclude there was a significant shift from warmer species, such as red deer, in the Allerød, to cold adapted fauna such as reindeer and horse during the YD, followed by a dramatic increase in numbers and species of warmer climate fauna into the PB. If the results of this analysis hold true, this would suggest, in warmer conditions, with more stationary prey such as red deer, human populations practised a more residentially mobile strategy, possibly as resources remained equally dispersed within the landscape and moved very little. With the onset of the YD and the disappearance of warm climate, and more stationary species, to the dominance of highly migratory reindeer and highly mobile wild horse, dispersed in a more open landscape, a higher level of logistical mobility seems to be preferred. Interestingly with warmer climates and the return of red deer, and the closing of the environment during the PB, there does not seem to be a similar mobility response to that seen in the Allerød, despite many climatic and environmental similarities between the two phases.

South Europe

Unlike the northwest, there is a much more developed and detailed account of faunal changes during the Lateglacial and Early Holocene in south Europe, and there is a long tradition of interpreting human behaviour from the readily available data from faunal assemblages found in this region, a sample of which will be discussed in the following section.

The warming episode of the Allerød led to an expansion of taxa out of areas of refugia throughout northern Spain, with forest ungulates, such as red deer, becoming the dominant species, and indicating a climatic improvement (Jones, 2016). The colder adapted species, such as reindeer, migrated northwards to colder climates, with the exception of the French southwest, where reindeer continued to persist (Straus, 1991). In Cantabria, Magdalenian populations had already developed a diverse subsistence strategy, and exploited a wide range of food resources, most notably red deer and molluscs, while along the southern edge of the Aquitaine basin, populations were becoming increasingly specialised in hunting reindeer. Across northern Spain and southwest France, there was an increase in mountain ibex exploitation and in northern Spain, other open country taxa such as bison and horse, were also important (Straus, 1991). It should be noted reindeer were never a major element of the Cantabrian faunal assemblages in any of the periods in this study, and they only appear to have a brief importance in the Allerød during an apparent period of reindeer expansion, which corresponded with a time of high population density of the species in southwest France (Straus, 1991). At this time, the dominant faunal remains found at sites in the western and central Pyrenees were from reindeer. However, at other terminal Magdalenian sites, ibex is the dominant exploited species in the high mountains, while other faunal assemblages are dominated by red deer, with some sites containing two or three important exploited species (Straus, 1991). The importance of red deer in northern Spain is seen in the study by Garcia-Guixe et al. (2009). The isotope evidence from the Allerød dated Balma Guilanya rockshelter in the pre-Pyrenees (1157 masl) in Catalonia suggest the majority of human dietary protein came from the consumption of herbivores such as red deer. The other major components included wild goat, and to a lesser degree, wild rabbits. Neither the zooarchaeological or stable isotope analysis provide any evidence for the exploitation of marine or freshwater resources, thus the fact marine shell ornaments are found onsite, suggests populations in this region were engaged in a long-distance exchange system (Garcia-Guixe et al., 2009).

In southern France, Jones (2016) finds there appears to be major changes in fauna that can be related to the warming of the Allerød, where there is possible evidence for significant changes in the composition of faunas, with cold adapted taxa decreasing, warmer taxa increasing, and an increase in the representation of lagomorphs. However, these changes seem to offset each other as there are no changes in evenness or richness values. In this region, there appears to be a replacement of one set of exploited fauna by another, rather than an expansion in diet breadth (Jones, 2016). In contrast to the red deer dominated assemblages of Vasco-Cantabria, Aquitaine sites during the Allerød are usually overwhelmingly dominated by reindeer which were never a significant game species during the entire Late Palaeolithic in Cantabrian Spain (Straus, 2011). The only similarity between the Spanish and French regions is that they both have mountain sites whose faunal assemblages are almost entirely composed of ibex (and sometimes chamois) (Jones, 2016).

There is virtually no difference between the Allerød and YD faunal assemblages in Vasco-Cantabria despite there being a distinctive change in the environment over large areas of the region to more open landscapes, suggesting there is strong continuity between the periods, which is in direct contrast to that seen in northwest Europe. The YD assemblages continue to be dominated by red deer, and others by ibex (Straus, 1991; Straus, 2011; Barbaza, 2011), while horse and bovids are still represented but in notably smaller numbers (Straus, 2011; Barbaza, 2011), but were more abundant in northern regions than southern regions (Aura et al., 2011). However, wild boar and roe deer that are occasionally present in Allerød/Late Magdalenian levels, begin to be more frequently found in higher percentages in YD/Azilian levels (Straus, 1991; Straus, 2011 Barbaza, 2011), although Straus (2011), notes it cannot always be specified as to whether these levels correspond to the Allerød, YD, or PB due to the scarcity of associated radiocarbon dates, thus one should advise caution when interpreting what exact subsistence behaviour was practised in any one period in this region. There is also additional evidence of the exploitation of small game and carnivores (rabbit, hare, birds as well as lynx, wild cats, and foxes) in regions such as Mediterranean Spain. Aura et al. (2011), see this more varied diet as a response to Mediterranean regions being more influenced by aridity than Euro-Siberian ones. Importantly, there is no YD cold-climate faunal signal in northern Spain (Straus, 2011). However, Barbaza (2011), does detect minor shifts in response to the YD in northern Spain, such as in the Euro-Siberian Iberia region, where the loss of the reindeer seems to have resulted in a slight restriction in mammalian diversity (Barbaza, 2011).

The continuation of red deer in more open and colder environments of the YD might seem unusual. However, red deer have long been misrepresented as a strictly woodland species found within temperate regions, but is now understood as being extremely versatile and flexible, living in open heaths, grasslands, parklands, and forests. Red deer have a huge modern day latitudinal range (Straus, 2011), and García Codrón (1996), García Moreno (2007), Marín-Arroyo (2009), Stevens et al. (2014), all agree red deer are capable of occupying a wide variety of environments and climates from the Magreb to Scandinavia, and that they are more affected by food shortage caused by extreme weather such as heavy snow or severe drought, than temperature (Marín-Arroyo, 2009). Furthermore, proportions of ibex or chamois would also not have been affected by changes in the palaeovegetation and palaeoclimate. Ibex are capable of occupying environments from 200 masl to 3300 masl, and woodland habitats are used by females during breeding seasons and are an important source of food procurement when pastures are scarce (García Codrón, 1996; García Moreno, 2007; Marín-Arroyo, 2009; Stevens et al., 2014).

In Italy, the picture is slightly different, with middle-sized ungulates still dominating the faunal assemblages, but containing substantial numbers of ibex and horse, while red deer is commonly represented (Mussi and Peresani, 2011), but not as dominant as seen in the northern Spanish assemblages. Birds, hare, fish, and molluscs (Mussi and Peresani, 2011), along with wild boar, hare, wild cat, and foxes (Visentin et al., 2016), were also important at some sites in Italy, which is also seen in northern Spain and southern France during this period. There is also evidence in northern Spain suggesting an exploitation of a wide range of marine resources in coastal areas with evidence for marine mammals, birds, fish, shellfish, urchins, and crabs (Aura et al., 2011), which shows there was a distinct increase in the importance of marine resources during the YD (Marín-Arroyo, 2013). Marín-Arroyo (2013) believes this to be due to the dramatic fall in the number of hunted ungulates in the region, rather than the exploitation of secondary, more predictable resources in a broadening diet.

Reindeer is totally absent from the YD dated Azilian faunas of Vasco-Cantabria, but it continues to be represented in small quantities in the Azilian of Dumthy, Dufaure, and Mas d'Azil, in southern France, which all date to the YD and PB (Straus, 1991), and there is debate as to whether reindeer existed in other refugia during the YD in the region at sites such as, Morin (Gironde), la Gare de Couze (Dordogne), Saint-Eulalie in the Lot, or Gazel layer 6 in the Aude (Straus, 1991). However, other than these sites, there is a complete disappearance of reindeer in the Cantabrian Mountains (Altuna and Mariezkurrena, 1996), the Alps and the Jura (Bridault et al., 2000), the Languedoc and the Massif Central (Bridault and Fontana, 2003), and the Pyrenees (Barbaza, 2011).

The onset of the PB brings about an abrupt change in subsistence practises, with a varied response from region to region (Straus, 1991). Reindeer almost disappeared and roe deer and wild boar become common within faunal assemblages for the first time. Horse disappeared during this period (Straus, 1991; Mussi and Peresani, 2011), and aurochs possibly replaced bison, while fish and molluscs seem to be of increasing importance, continuing the trend from the Allerød and YD (Straus, 1991). This dramatic change is also seen in Italy, where ibex hunting grounds were only found in the refugia of higher mountains, whereas they were previously found at lower altitudes (Mussi and Peresani, 2011).

Marín-Arroyo's (2013) study on the responses to the Holocene warming found that along the Cantabrian coast there was an increase in diet breadth, but with less ungulates species exploited, which could only be explained if the population density of previously hunted species, mainly red deer and ibex, had significantly decreased, and a greater variety of other non-ungulate species were introduced into their diet to compensate. Marín-Arroyo (2013) believe intensification of marine and lake resources were not sufficient enough to explain the decrease in ungulate exploitation as the amount of energy provided (as far as the available archaeological record is concerned) and that there is clear evidence of ungulate over-exploitation during the YD and Early Holocene, such as the increase in the hunting of juvenile individuals, the reduction in the exploitation of ungulates, and the enlargement of catchment areas. Estévez (2005) and Marín-Arroyo and González Morales (2009) suggest a rapid decrease in temperatures during the PB, caused by the sudden interruption of the North Atlantic oceanic circulation from 11,000 to 8000 cal BP, might have caused a catastrophic reduction of terrestrial resources that in turn could have dramatically affected the Cantabrian human populations. This kind of climatic instability could have been the cause of the collapse in the ungulate populations that were simultaneously being overhunted by human populations in some regions. Marín-Arroyo (2013) believes this kind of rapid resource depletion would have forced human groups to migrate to other, less affected, areas for survival. This is one example of the effects of the climatic instability during the PB (discussed in Chapter 1), which may be responsible for the almost universal evidence of major shifts in subsistence and settlement strategies during the Early Holocene rather than the generally more climatically severe YD.

7.5 - Summary of the Northwest and South European Faunal Evidence

Overall, it seems the availability and exploitation of fauna in the south was very different from that in the northwest. There is little evidence across south Europe (with the exception of the pre-Pyrenees region in France) of any significant change in faunal species composition from the Allerød to the YD, with red deer and ibex being the predominately exploited species in both periods, and no cold climate ungulate signal at all is evident in northern Spain (Straus, 2011). However, there is evidence in northern Spain for a potentially catastrophic decrease in ungulate populations at the end of the YD that caused a shift to a diet more focused on marine resources. Conversely, in the northwest of Europe, there appears to be a rather more uniform transition of warm climate fauna during the Allerød, to cold climate fauna in the YD, and a return and expansion of warm climate fauna with the onset of the PB. This asks the question, if there was no major change in species composition and exploitation from the Allerød to the YD in south Europe, why is there a small, but apparent, change in mobility strategies from more logistically mobile populations in the Allerød to more residentially mobile populations in the YD? This might be related to hunting game species in different environments, as the same species (mainly red deer and ibex) must have been a different prospect to hunt in a more open landscape compared with a densely forest one. This contrasts with the northwest where there was a complete replacement of major game species, such as red deer, to reindeer, in a cold and open landscape. This must have necessitated a distinct shift in mobility, which is seen from the analyses in this thesis.

It has also been shown in Chapter 5 that the major changes in hunter-gatherer mobility behaviours in the south again only occur during the Holocene, not the YD, in which the only statistically different and dramatic changes in mobility occur during the PB, where there is a large shift to a more logistical system.

The difference between the northern Spanish and the southwestern French faunal records would be interesting to investigate to see if the indicators of this study would highlight different responses to the different subsistence strategies most likely employed in these regions. However, the French sample in this study is very small, and probably has little bearing on the results, which predominately consist of sites from Spain and Italy, both regions of which have an absence of reindeer, and rely heavily on red deer and medium-sized ungulates. This may be a good candidate for continued future research.

7.6 - Initial Conclusions

The results of this study show human populations can continue to survive in a variety of conditions, and adapt accordingly to changes in their environment. There is no strong evidence there is any kind of mass migration from the harsh conditions in the north of Europe during the YD, but strong evidence suggesting they remained in the region and changed their settlement and subsistence strategies to exploit new cold adapted species, which replaced previous warmer climate species. In the south, there is little evidence human populations dramatically changed their behaviour with the onset of the YD, despite the distinct changes in climate and environment. However, the warmer climate faunal species were not replaced with the onset of the YD. Thus, it appears changes in mobility are more related to the differences in the faunal species present within a region, than to the changes in climatic and environmental conditions, and that faunal species only appear to significantly change in regions affected by extremes in climate change. These conclusions are based on a narrow set of data, focusing solely on changes in stone tool compositions. Thus, it is important to compare these results with other studies into the YD, and other major climate change events, in order to put this study into context.

7.7 - Comparative Studies in Northwest and South Europe

Firstly, comparisons will be made with other studies within the same regions of northwest and south Europe, and expand to other regions in Europe and then globally. Unfortunately, studies into hunter-gatherer mobility changes related to the YD in northwest Europe are sparse, with the majority of studies focusing on the Late Glacial/Early Holocene with only brief mentions of the YD, mostly recognising its existence and glossing over any potential importance it may have had on human evolution. However, in comparison, there is a much larger body of literature (especially more modern literature) in the south of Europe, which allows an in-depth discussion.

In the U.K. Pettitt and White (2012), hypothesise the evidence (or scarcity of) strongly suggest there was a marginal occupation of the U.K. during the Allerød, noting the greater interest in open-air sites, and with the advent of the YD, the human occupation was even more marginal, and inferred cave use stopped during this phase. Thus, they believe human occupation in this region was likely limited to nothing more than a few months towards the end of the period during the YD. However, they support the Long Blade industry as a facies of the Ahrensburgian on the continent. They also show Federmesser populations during the Allerød appear to have shifted to a strategy focusing more on localised raw materials compared with the previous Bølling phase, which then shifts to a strategy focused more on non-local materials into the YD. They support this with evidence from the Vale of Pickering in Yorkshire, which seemingly suggests ready-made tools were imported and supplemented by a small number of blades and cores sourced from the east of Doggerland. This, they argue, represents a strongly different strategy to the previous populations which used local flint, and interpreted this as a strategy of provisioning groups in a flexible mobility strategy in which there was no need to schedule specific trips to obtain lithic resources. However, Lewis and Rackham (2011) find at the site of Three Ways Wharf, that tools were manufactured from mostly local river cobbles in southern England, this behaviour is also seen at Avington (Froom,2005), which suggest a variety of raw material sourcing strategies may have been utilised. Pettitt and White's (2012) vision (rightly based on the empirical evidence) of YD human occupation during the YD, seems to be one of highly mobile and brief occupations in the U.K, which one might suggest suits short, targeted, logistical forays in this region. However, despite this lack of evidence in the U.K., I strongly believe the majority of sites from this period have not been found or recognised, as the number of professional excavations targeting this period in the U.K. are few and far between. Conditions and available faunal species, especially in the south of England, were very similar to those in northern France, Belgium, and the Netherlands during the YD, so why should the settlement be any different?

In northwest Europe, Barton (1991) stresses there was a lack of significant changes in the toolkits from the Allerød through to the early PB in the U.K. evidence. There are only major changes in tool technology evident around the late/mid PB, and he believes this coincides with the expansion of closed forest and rise in hazel, along with the appearance of woodland fauna in hunting assemblages. This period also saw the introduction of axes/adzes, which he believes to be directly related to the expansion of dense forest and human woodworking. Thus, changes in human behaviour seem to have been made necessary due to the spread of denser woodland in areas of northwest Europe, rather than to dramatic changes in environment and game species. This finding of technological continuity through the majority of the period of this study might lead one to conclude that there was no major change in mobility between the Allerød, the YD, and potentially the PB. However, this is not what is seen from the results of my study, in which there appear to be clear changes from a more residential strategy during the Allerød, to a more logistical strategy during the YD. The PB sees a shift back to a more residential strategy, but this is much more subdued compared with the Allerød/YD mobility shift, with several similarities to the YD tool compositions. Perhaps this provides supporting evidence for a continuity in tool technologies at least from the YD into the part of the PB (which is further supported by the continuation of the Long Blade industry in the U.K., Netherlands, Belgium, and northern France [Lewis and Rackham, 2011; Froom, 2005; Jacquier, 2014]), and the Ahrensburgian in the Netherlands, Belgium, and northern Germany (Mithen et al., 2015; Deeben and Schreurs, 2012) that persist from the YD into the mid/late PB). However, there was a major break in the faunal game species during the YD (i.e. from red deer to reindeer) in the northwest, as one would predict, resulted in a distinct change in technological organisation. It appears that this reorganisation, if it occurred, involved the adaptation of the same technologies, rather than the invention of new ones, or that a change in toolkit is yet to be discovered.

Crombé et al. (2014) claim the site of Ruien, Belgium, perhaps provides evidence of an abrupt change in tool manufacturing techniques with the onset of the YD. This technology is characterised “by the use of a soft stone hammer and the production of straight and regular blade(let)s from intensively prepared cores with two opposite platforms and sharp striking angles” (Crombé et al., 2014: 420). They also find there was an increase in raw material procurement networks and a marked microlithisation of hunting tools. This marked increase in microlithisation can be seen from the results of the data presented in Chapter 4, but is followed by an even more pronounced microlithisation from the YD into the PB, so this is unlikely to be related solely to climate change. There is no evidence from the results that show a difference in long distance procurement in raw materials between any of the periods. The results of Crombé et al. (2014) study are based on one, small, site in Belgium, and cannot be considered representative of all sites belonging to the YD. Thus, large-scale interpretations into changes in YD human behaviour cannot be made, but it is interesting that potential, subtler, changes in tool technologies are starting to be recognised during the YD.

Eriksen (1996) finds in northwest Europe, compared with the Allerød, the YD organic assemblages of the Ahrensburgian tend to be very large and dominated by Reindeer, while Allerød assemblages are smaller and dominated by elk. One example of these larger YD camps is the Ahrensburgian site of Stellmoor, which has been interpreted as an aggregation camp, and the strong evidence of the use of bow and arrow technology at this site appears to be distinctly different from the previous Federmesser population's whole likely relied on spears and spear throwers. This finding of larger camps during the YD, might support the findings of this study that north-western hunter-gatherers were more logistically mobile, possibly representing base camps, and that the smaller sites during the Allerød represent smaller mobile camps in a residential strategy. However, there is no strong evidence from this study suggesting there are any statistically significant differences in site/excavation size of the analysed sites through any of the periods.

Jones' (2016) study into the Broad Spectrum Revolution in southwestern Europe, used differences in site elevation variance to observe any changes in mobility behaviour. She hypothesised, if site elevation variance is high, sites are dispersed across a variety of elevations; and if variance is low, they are concentrated at a particular range of elevations. This leads to the predictions summarised below:

Residential mobility > Predictable resources > Frequent movement > High site altitude variance
Logistical mobility > Less predictable resources > Infrequent movement > Low site altitude variance
(Jones, 2016)

Thus, if a region contains a high site elevation variance, she predicts a patchy environment and a more residential strategy should be employed. Conversely, if a region contains a low site elevation variance, this suggests resources are more scattered across the landscape less predictably, and thus populations may have practised a logistical strategy. Her results found, with the exception of southern France, there was no significant evidence to suggest site elevation variance changed through time in the Late Upper Palaeolithic in S.W. Europe. However, there does seem to be an increase in variance, which she associates with an increase in residential mobility, during the Epi-Palaeolithic, which includes the YD (Jones, 2016). Unfortunately, the YD is not treated as a separate entity, so a direct comparison to this author's study is difficult, but does potentially agree with the findings here, that south populations during the YD were more residentially mobile.

When observing the altitude variances of assemblages from this study, there are distinctly higher variances in the south sample. This difference is notable between the variances of the whole datasets and between each climatic phase (see Table 7.1). According to Jones (2016), this would support the findings of this study, in that the south assemblages are generally more residentially mobile than the northwest populations. However, the variance of the YD in both samples are lower than the Allerød and PB, which suggest, according to Jones (2016), they are more logistically organised during this period. This supports the finding here, in the northwest sample, but does not agree with the findings of the south sample, although the difference in variance between the Allerød and YD is comparatively small and might represent little change in mobility between these periods, in which case this offers a level of support. The PB in the south also has a considerably higher variance than the YD and the Allerød, suggesting populations during this period were much more residentially organised in the south. Her results contradict the findings in this thesis, which found the populations during the PB were distinctly more logistically organised. Interestingly, in the northwest there appears to be a more subdued increase in variance from the YD into the PB, compared with the Allerød into the YD, and in the south, the Allerød, and YD appear to have relatively similar variances, while the PB has a distinctly higher variance. These differences seem to be a characteristic between these periods in the majority of the analyses in this study, although their interpretation relating to the exact form of mobility organisation is not always consistent. This also tentatively agrees with Jones (2016) that there is no significant change in variance in the Late Palaeolithic in south Europe, although there does appear to be some evidence for a slight decrease from the Allerød into the YD.

	N.W. Altitude Variance	South Altitude Variance
Whole Dataset	6939.466	264159.707
Allerød	8300.111	199524.464
YD	4450.089	155756.637
PB	5204.192	431898.062

(Table 7.1: Comparison of the variance of altitudes of sites between the northwest and south European samples)

The comparison of altitude variance also questions how site altitudes change in the northwest and south European datasets. Looking at the mean altitudes of sites in this study from both regions (Tables 7.2-7.7) there is a distinct difference in the average altitude between the northwest and south regions, which is a result of the different geology of the regions. The south region is much more mountainous than the lowlands of northwest Europe, and thus, a direct comparison of altitudes is not feasible. However, notably, there is no statistically significant difference in mean altitudes across any of the climatic phases in the south, suggesting little change in human habitat ranges in response to climate change. These results are similar to those found from other research in this region, in that there is no observable difference in altitudes between the Allerød and YD. However, the fact there is also no observable difference into the PB is surprising, as this period is considered to be a time of major subsistence change. In comparison, in the northwest, there is a statistically significantly lower mean altitude in site location during the PB, especially when compared with the Allerød. This suggests populations during the early Holocene in the northwest located their sites at lower altitudes, which might be expected in a more residential strategy. This is contradictory to many of the results of this study, which appear to suggest populations during the PB were notably more logistically mobile than the Allerød. There is no observable, statistically significant, response in altitude of sites from the Allerød into the YD in the northwest, which would have been expected with a shift to a more logistical strategy in harsher conditions, but this appears not to be the case. However, the mean altitude is notably lower than the Allerød, which is also surprising, as a more logistical population would be expected to make use of a wider range of altitudes within a landscape at any one time.

Northwest Europe Mean Altitudes

	μ	n	σ	σ^2
Whole Dataset	65.161	262	83.303	6939.466
Allerød	79.817	83	91.105	8300.111
YD	62.770	48	66.709	4450.089
PB	49.581	74	72.140	5204.192

(Table 7.2: Mean altitude in northwest European assemblages for the whole dataset and each climatic phase)

The results of the Kruskal-Wallis rank sum test (H(2) = 16.693, df = 2, p-value = 0.0002), show there is a significant relationship between mean altitudes between climatic phases in the northwest dataset. A MW-U test (table 7.3) confirms the Allerød and YD are significantly different from the PB, and is further confirmed by Dunn's test (Table 7.4).

	U	p	Significance
Allerød and YD	2234.5	0.247	Not significant
YD and PB	1260	0.007	Significant
Allerød and PB	4173	0.0001	Significant

(Table 7.3: Mann-Whitney U test for significance between the northwest European assemblages mean altitudes)

	Z	p	Significance
Allerød and YD	0.976	0.493	Not significant
YD and PB	-2.508	0.018	Significant
Allerød and PB	4.014	0.0001	Significant

(Table 7.4: Dunn's Test with Bonferroni correction for significance between the northwest European assemblages mean altitudes)

South Europe Mean Altitudes

	μ	n	σ	$σ^2$
Whole Dataset	647.735	136	513.965	264159.707
Allerød	555.261	46	446.682	199524.464
YD	663.595	37	394.660	155756.637
PB	757.442	43	657.190	431898.062

(Table 7.5: Mean altitude in northwest European assemblages for the whole dataset and each climatic phase)

The results of the Kruskal-Wallis rank sum test (H(2) = 1.7675, df = 2, p-value = 0.4132), show there is no significant relationship between the mean altitudes between climatic phases in the south dataset. This is confirmed by the MW-U test (Table 7.6) and Dunn's test (Table 7.7).

	U	p	Significance
Allerød and YD	720	0.232	Not significant
YD and PB	795	1.000	Not significant
Allerød and PB	858	0.284	Not significant

(Table 7.6: Mann-Whitney U test for significance between the south European assemblages mean altitudes)

	Z	p	Significance
Allerød and YD	-1.147	0.377	Not significant
YD and PB	-0.063	1.000	Not significant
Allerød and PB	-1.127	0.389	Not significant

(Table 7.7: Dunn's Test with Bonferroni correction for significance between the south European assemblages mean altitudes)

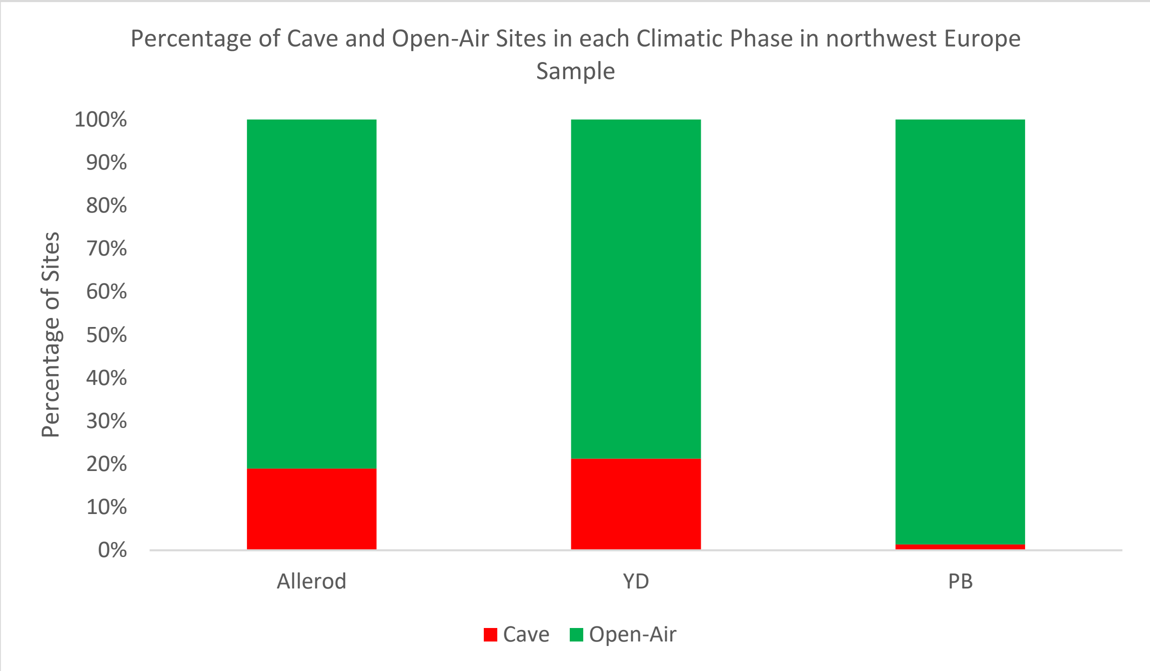
In the south, Aura et al. (2011) found the distribution of sites during the Allerød and YD are virtually identical and are essentially all in caves and rockshelters, while open-air sites notably increase during the Mesolithic. There are a large number of sites dated to the YD overlying sites dated to the Allerød, which suggests there is a continuity in settlement choices between these two climatic phases (Straus, 1991; Straus, 1996; Aura et al., 2011). Both the Allerød and YD sites are distributed between lowland and highland zones, with sites on the coast, and also in mountain areas, even above 1000 masl (Straus, 1991; Aura et al., 2011). However, there is a relative paucity of YD sites in the high Pyrenees. Overall, it appears the same kinds of decision making were made by hunter-gatherers in choosing locations of sites in these two periods (Straus, 1991; 2011).

The data from this study may support the argument that in the south, cave sites are the dominant site type during the Allerød and YD, and there is a notable increase in open-air sites containing lithic assemblages into the PB (Fig 7.2). In comparison, the majority of sites with lithic assemblages during the Allerød, YD, and PB in the northwest in this dataset, are from open-air sites (Fig 7.1), which may indicate a significantly different settlement organisation was in place in northwest Europe, even during the warmer interstadials. However, there appear to be notably more cave sites containing lithic assemblages in the Allerød (n = 11) and YD (n = 10), than during the PB (n =1).

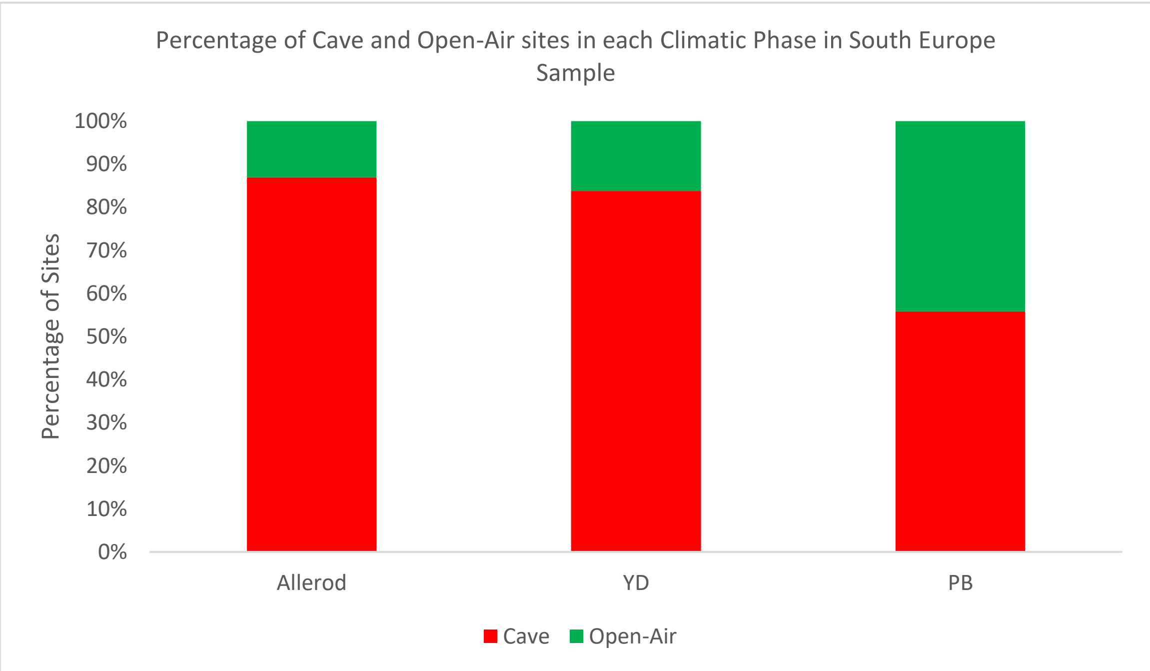
In the data evaluation in Chapter 3, it was found that a large proportion of cave sites with lithic assemblages were discovered pre-1960 and were thus excluded in the B/T ratio analysis, as there was a notable bias towards tool recovery over blanks, but perhaps cave sites naturally have a lower number of blanks as a component of site function. Does the fact the majority of sites in the south sample are from cave sites, explain the differences seen in tool assemblage compositions and the interpreted mobility strategies?

The Gamble et al. (2004) study found there was a distinct increase in the numbers of open-air sites into the YD in northwest Europe, relying on the C14 date frequency data. They express this in terms of settlement patterns, in which there was a move to larger aggregation campsites during the YD, from more scattered occupations across larger regions during the Bølling-Allerød, shown by habitual use of caves and rockshelters. They note it is interesting that the preferred settlement pattern during the Holocene was also for open locations. These observations are not supported by my data, where there is no observable change in the numbers of cave and rockshelter sites containing lithic assemblages from the Allerød into the YD, although open-air sites dominate both these periods. It is the environmental conditions of the PB where we see almost all lithic assemblages are from open-air sites. However, the

Gamble et al. (2004) observations are also not refuted by this study, as this dataset does not include sites that lack lithic assemblages and contain only organic artefacts and/or remains.



(Fig 7.1: Percentage of cave and open-air sites containing lithic assembalges in northwest European sample)



(Fig 7.2: Percentage of cave and open-air sites containing lithic assembalges in south European sample)

The statement that there is a shift to larger aggregation camps during the YD is also not supported, there being no statistically significant difference between site/area of excavation sizes of the Allerød and the YD periods (Table 7.8). However, the Allerød has notably higher mean site sizes, which if anything, suggests sites during the YD were smaller than those in the Allerød, not larger as Gamble et al. (2004) hypothesise. There is evidence for a statistically significant difference between the YD and PB, where the PB have larger site sizes, which might explain the dominance of open-air sites during this phase if one assumes large sites are not located within caves.

	μ	n	σ	σ^2
Whole Dataset	3743.730	154	21811.329	475734062.800
Allerød	8532.098	48	37421.651	1400379993.000
YD	1305.710	31	4131.422	17068649.150
PB	2753.390	43	10618.024	112742435.100

(Table 7.8: Mean size of site/area of excavation in m2 for each of the climatic periods in northwest Europe)

The results of the Kruskal-Wallis rank sum test (H(2) = 4.0783, df = 2, p-value = 0.1301), show there is no significant relationship between the mean site sizes/area of excavations between climatic phases in the northwest dataset. However, the sites from the YD are statistically significantly smaller than those of the PB in the MW-U test (Table 7.9), but no statistical significance was found using Dunn's test (Table 7.10).

	U	p	Significance
Allerød and YD	893	0.136	Not significant
YD and PB	850.5	0.044	Significant
Allerød and PB	976	0.659	Not significant

(Table 7.9: Mann-Whitney U test for significance between the northwest European assemblages mean site size/area of excavation)

	Z	p	Significance
Allerød and YD	1.557	0.179	Not Significant
YD and PB	1.960	0.075	Not significant
Allerød and PB	-0.491	0.935	Not significant

(Table 7.10: Dunn's Test with Bonferroni correction for significance between the northwest European assemblages mean site size/area of excavation)

Straus (1991) finds that many important base camps were located in the coastal zone of Franco-Cantabria during glacial conditions such as the YD, where logistical forays were organised into the upland regions to hunt ibex or red deer. He predicts, under these conditions, ibex may have descended farther in winter and red deer ascended less in summer than in interstadial periods. Thus, he believes inland sites used in winter for specialist ibex hunting during the YD, could have been used in summer during the PB for red deer hunting (Straus, 1991). He, strongly suggests populations during the YD would have practised a more logistical system with specialised inland ibex hunting, but this is not what we see from the tool assemblages in this study, which suggest a slightly more residential behaviour during the YD, or very little change in mobility at all, from the Allerød to the YD. This is more in line with many studies in which we see little change in faunal availability and hunter-gatherer prey choice between the Allerød and the YD in the south of Europe (Straus, 1991; Straus, 2011; Barbaza, 2011; Aura et al., 2011). This is supported by studies, such as by Marín-Arroyo (2009), that propose greater sedentism would explain the evidence for seasonal specialisation in settlements belonging to the Magdalenian, while there appears to be diversification during the YD, despite more severe climatic conditions.

Further evidence for human population continuity is seen in the numbers of sites in northeast Spain, which are very similar between the Allerød and YD, and the YD does not seem to have affected hunter-gatherer population demographics. Instead the most obvious changes in stone tool manufacturing techniques, subsistence, mortuary practices, and art, date to the Early Mesolithic (Aura et al., 2011). During this period, there are new tool styles, a shift towards forest subsistence exploitation, and the end of the portable art tradition. Aura et al. (2011) believe this to signify a major increase in social complexity linked with changes in demography during the amelioration of the Holocene. This may be supported from the results of this study, which finds the only distinct and significant shift in tool compositions occur in the PB in the south dataset. However, this is not to say there were not important changes seen in YD populations in south Europe. Aura et al. (2011) see three important cultural changes with the onset of the YD in south Europe; the end of the Palaeolithic parietal art and portable art; the abandonment of bone and antler as a raw material for complex tools and ornaments; and a general trend towards microlithisation. These changes might be represented by the possible, slight, increase in the level of residential mobility during the YD in the south dataset.

In Italy, Mussi and Peresani (2011), highlight the wide range of environments settled by human populations during the YD, ranging from coastal areas, river valleys, lake basins and high mountain ranges (as high as 1500 masl). They found, in the pre-Alps, the same mountains and high elevation hunting grounds were occupied between the Allerød and YD, similar to the behaviour seen in northern Spain. However, there is evidence of changes in settlement patterns, with the utilisation of smaller, and shorter occupied camps, during the YD compared with those in the previous Allerød (Mussi and Peresani, 2011). From this, they conclude, although there were markedly colder conditions during the YD, there is limited evidence for hunter-gatherer stress in Italy, even in high altitude Alpine areas. In the alps, it appears some earlier, Allerød, sites were no longer in use during the YD, where new, smaller camps, occupied for shorter periods, were favoured. This suggests the same areas were occupied, but within a different, more mobile strategy. Overall, they conclude hunter-gatherers were remarkably resilient in the face of climate change in Italy (Mussi and Peresani, 2011), much in the same way as in northern Spain and southern France, and further supports the finding from this study that more mobile strategies were employed during the YD in south Europe.

Jones' (2009) study into zooarchaeological remains at the site of Pont d'Ambon, south France, found human populations consistently exploited a large number of smaller game in a broadening diet that was in place since the Allerød. These assemblages are frequently dominated by wild rabbits rather than large game, which is unusual for this region. There is no evidence for reindeer at this site, and the large ungulates consist mainly of red deer, aurochs, and horse. European rabbit, a warm climate species, commonly exploited during the Allerød (comprising up to 90% of the faunal assemblages), persist into the YD, despite the significant decrease in annual temperature and precipitation. Their persistence during this colder phase is thought to be due to summer temperatures not being severely affected. However, a significant decrease in patchiness to open grassland would have significantly affected the European rabbit's habitat and lowered their populations. She believes the human response to this appears not to shift to the exploitation of larger game in this colder climate as did the previous Magdalenian populations of the region, rather to intensify their use of the decreased European rabbit populations, evidenced by increased taking of juveniles, and increased frequency of cutmarks, and marrow processing. This provides evidence of a significant shift in subsistence practice that can be related to the changing climate and environment during the YD. Jones (2009) notes another response seems to be that fish decreased in relative abundance, while rabbits and birds increased. This shows a change in subsistence organisation as a response to exploiting the same species, but in a different environment, but there was unlikely to be a significant change in mobility, at least relating to faunal exploitation, but simply an intensification of an already heavily utilised resource. This might be evidence for the importance of subsistence traditions within hunter-gatherer populations. Rabbits were a reliable source of food for their ancestors and they continued to heavily exploit them as they persisted into the YD, albeit in smaller numbers, rather than shift to higher return, larger game animals.

Finally, one of the most distinct differences between the north-western and southern Europe is the extent of the mountainous terrain in the south. Garcia-Guixe et al. (2009), highlight the human colonisation and occupation of mountain regions in the Lateglacial is a highly complex issue when presenting their research from the site of Balma Guilanya in pre-Pyrenees Spain, stating the fragmented nature of mountain environments can stimulate plant and animal biodiversity, which can provide a variety of subsistence opportunities for hunter-gatherer populations. However, they importantly note these potential subsistence opportunities were only generally available during brief or seasonal periods and, consequently, the human occupation of these regions would have required planning and scheduling to determine when and where to move to optimise the exploitation of these resources (Gamble, 1993, cited in Garcia-Guixe et al., 2009). This predicted planning and scheduling would suggest populations that exploited these landscapes would have had to practise a more residential strategy (at least when defined by the theories around cost, risk, and anticipation described in Chapter 2) and might be responsible for both the generally greater residential mobility signal seen in the south across all the periods of study, and the possible increase in residential mobility seen during the YD in the south.

These studies all agree with the conclusions here that human populations had no issues in persisting within their respective regions during the climatic downturn of the YD, and that in the south there was little change in subsistence strategies, as many warm climate species continued to populate the region, but how do these conclusions compare with YD studies from farther afield?

7.8 - Comparative Global YD Studies

The global climate change associated with the YD affected different regions of the northern hemisphere in different ways. We have seen the harsh conditions seen over large parts of northwest Europe, and the comparatively subdued response in south Europe, but how did the YD affect human populations on other continents?

7.8a - North America

There is a robust and continually expanding body of research on the impact of the YD on Paleoindian populations in North America, providing a good comparison for the results of this study. Key case studies from several of the major regions within the U.S. will be presented here, and then discussed in terms of the findings of my research.

Over large parts of the U.S., there was a distinct cooling during the YD, accompanied by an increase in moisture (Goebel et al., 2011; Ballenger et al., 2011; Anderson et al., 2011; LaBelle, 2012; Meltzer and Holiday, 2010). Goebel et al. (2011) believe, in the Great Basin, this had a positive effect for hunter-gatherer populations, with wetter conditions in this region leading to the formation of shallow, but permanent lakes and a diverse number of faunal species. They see the YD in this region to be "…..one of the most favourable times for human foragers in this region of North America" (Goebel et al., 2011:479). However, Anderson et al. (2011), in the American Southeast, noted there are several sites that provide evidence for different climatic responses, with some regions warmer and wetter, while others colder and drier. This might show the potential for environmental enclaves with differing microclimates, which, as has been seen in the research by Goebel et al. (2009) in the mountainous regions of northern Spain, may facilitate the development of varied faunal and floral species that require scheduling and planning to exploit, and thus might forward the prediction that populations in the American Southwest during the YD would be more residentially mobile.

In terms of the lithic evidence, Goebel et al. (2011) find populations during the YD in the Great Basin region, manufactured stone tool assemblages that were mostly designed for longer curation, suggesting a more residential mobility was employed if we apply the expectations set out in Chapter 2 of this study, which is supported by their finding of evidence suggesting long-range transport of obsidian tools, the lack of caches suggesting short-term occupations of sites, and the limited use of local raw materials, which points to a "…..high-mobility settlement strategy in which whole groups moved to seasonally available resources" (Goebel et al., 2011:498). In another study in the Great Basin region, Smith (2011), used proportions of local and non-local lithic raw materials in Pre-Archaic and Archaic assemblages to ascertain the occupation length of sites across the Pleistocene/Holocene Transition, making the assumption assemblages should become increasingly dominated by local materials as occupation length increases, thus suggesting a less mobile population would have a higher proportion of local raw materials at a site, much as the predictions of raw materials and mobility set out in Chapter 2 of this thesis. They found there were lower local/non-local stone raw material ratios in the Pre-Archaic (which corresponds roughly with the YD and PB, before ca. 9500 cal BP), than compared with the Archaic (ca. 9500-6500 cal BP). This implies populations that existed during the YD/PB practised a higher level of mobility during the Pre-Archaic. Smith (2011:461) believes "…..these trends were likely influenced by changes in the environmental and demographic climate of the Holocene", most likely an increase in temperature and a decrease in precipitation after the YD. This decrease in rainfall led to the disappearance of most of the lakes and wetlands that developed during the YD, and thus would have had a major impact on human settlement organisation from a more mobile strategy during the YD, to a less mobile mobility strategy in the Early-Mid Holocene (Smith, 2011). This again highlights that a more mobile, and possibly more residential, strategy was employed by hunter-gatherer populations during relatively favourable periods, while a less mobile, possibly more logistical, strategy was employed during less favourable conditions, much as Binford (1980) predicts, and that is assumed in this thesis. The results of Smith's

(2011) study are similar to that seen in south Europe, in which case, one might presume this region of Europe had more favourable conditions for hunter-gatherer populations during the Allerød and YD, compared with the PB. This also supports and explains the results of this thesis that suggests, in northwest Europe, human populations practised a more logistical strategy during the YD, which was distinctly less favourable for human populations in this region compared with the preceding and subsequent Allerød and PB Interstadials.

The study by Meeks and Anderson (2012), also provides evidence there appears to be a shift in land-use in the Southeast U.S. at the beginning and end of the YD, which they believe is directly related to this event. The numbers of sites and artefacts reported suggest human populations and land-use was relatively low at the beginning of the YD, while there appears to be a rapid increase in population along with an increase in land-use at the end of YD. This evidence suggests there were small groups of highly mobile populations in a more residential strategy at the onset of the YD, and presumably throughout, followed by a dramatic increase in population and thus potentially a decrease in mobility (possibly to a more logistical strategy) at the start of the Holocene, as is reported in other parts of the U.S. and southern Europe, and also in the results of this study in southern Europe. A later study in the Southeast U.S. by Smallwood et al. (2015), who used point frequencies and raw material use as a proxy for human behaviour in the more localised region of Georgia, agrees somewhat with Meeks and Anderson (2012), in that they found, during the first few centuries of the YD, Georgia became sparsely occupied and populations became more concentrated around lithic raw material sources, while later in the YD, populations expanded, but with evidence of increased settlement away from the coastal plain and into more elevated areas towards the end of the YD (Smallwood et al., 2015). This suggests there were changes in human settlement organisation later within the YD, which fits the climatic evidence in Europe and many other parts of the northern hemisphere of a differing climatic signal in the second half of the YD, generally to a drier phase. Perhaps the initial response to the change to a wetter climate was to shift to a more dispersed and probably much more mobile strategy, and as the climate potentially became drier (and less favourable) in the latter half of the YD, a change to a less mobile strategy was a necessary adaptation. However, Smallwood et al. (2015), link this shift in land-use to the degradation of the coastal plain, as sea levels increased, and thus forcing populations to higher elevations. It may be of interest for future research in Europe to attempt to monitor changes in mobility and changes in the condition of coastal plain zones with rising sea levels.

Furthermore, LaBelle (2012) recognises three phases of human settlement patterns for the Pleistocene/Holocene Transition in the Plains and Rocky Mountains region, indicating there were human responses to YD climate change. These are; Colonisation; Clovis; and Folsom phases. In the colonisation phase, due to the small amount of discovered archaeological material, it appears the early populations in this region were small in number, highly mobile, and spent little time at sites, thus leaving little material remains (Labelle, 2012). This might suggest a more residentially mobile system would have been in place during this phase in this region. By contrast, in the Early YD dated Clovis phase (ca. 12,900-12,700 cal BP), there appears to be widespread human populations across the region, although in generally low frequencies. Labelle (2012) notes three distinct Clovis site types: Large numbers of small lithic scatters, usually containing a single Clovis point, and suggesting short-term and limited activity camps (LaBelle 2005); Tool caches, often containing large bifaces manufactured from raw material sources located up to several hundred kilometres away, which are interpreted as insurance caches related to initial or early colonisation of the region; and finally, very rare mammoth remains sites, which are often interpreted as kill sites. However, the Folsom lithic record, which can be directly associated with the YD, is dominated by small sites mostly containing isolated finds and small lithic scatters; less common, midsize sites, which have between ten and thirty points and preforms; and importantly, in terms of this thesis, a number of large residential base camps, which emerged in the region during this period (LaBelle, 2012). These large sites can contain up to at least 600 projectile points, in contrast to the earlier Clovis sites which contain sometimes a single point (LaBelle, 2012). LaBelle (2012), highlights Folsom groups are commonly argued to be highly residentially mobile based on the presence of non-local raw materials at sites. However, he finds that sites are beginning to be found indicating subtle regional differences between them, with some relying on non-local raw materials, while others, relying almost entirely on local raw materials. This leads LaBelle (2012), to conclude there was no one response to the YD, rather a mixture of mobility and subsistence patterns in different regions. He goes further to say Folsom sites in this region are often clustered around mountain basins, which, based on climatic reconstructions, must have been cold and dry compared with adjacent regions in the area. He interprets this settlement choice as evidence for logistical mobility, in which these sites were used for specialist tasks, away from a centralised base camp. Also, formal structures appear during this phase, and LaBelle (2012) believes this might indicate an adaptation to the colder YD, and supports his belief of the adoption of a less mobile mobility strategy. This belief by LaBelle (2012) of a more logistically mobile system during the YD in North America, disagrees with the majority of the studies presented here, that find a more mobile strategy was employed during the YD compared with the preceding and subsequent Allerød and PB, and disagrees with the opinion supported in this thesis that more favourable conditions (in this case conditions with higher levels of moisture) should promote a more residentially mobile strategy. This would suggest hunter-gatherer behaviour in response to the YD, at least in the U.S. Plains and Rocky Mountains, is similar to that of hunter-gatherer populations in the northwest of Europe, that were living in significantly colder, and less favourable conditions.

Lastly, in North America, a study by Anderson et al. (2011) found the YD may have had a significant effect on hunter-gatherer population dynamics across North America. Multi-proxy evidence from frequency analyses of Paleoindian projectile points; time series of lithic assemblages from quarry sites; and summed probability analyses (SPA) of radiocarbon dates, show a major decrease in human populations (possibly indicating a population bottleneck), or alternatively a reorganisation in settlement, occurred over large areas of North America at the onset of the YD (which appears to be the case from the evidence of much of the Northern Hemisphere). This change appears to have occurred rapidly, with evidence in some areas of human population declines of up to 30%-50%. However, in the latter half of the YD, there is evidence for an increase in population, indicated by increased numbers of projectile points, increased quarry usage, and the SPA datasets in most areas in North America. They note, in contrast to the onset of the YD, this increase in population took place during a time of continued climatic cooling, suggesting other non-climate related factors were influencing these changes (Anderson et al., 2011).

7.8b - Summary of North American YD Studies

The human response to the YD in North America is clearly a complex issue. The consensus is, there was a distinct shift in human settlement and subsidence behaviour, appearing to coincide with the YD. However, the exact response is highly variable from region to region, as one might expect in a country with such a wide-ranging geographic topography as North America. It is widely considered populations during the YD in this region were highly residentially mobile, in colder, and wetter conditions. In fact, the YD over much of the U.S. appears to be a much more favourable period for hunter-gatherers, especially in contrast to populations in the northwest of Europe. This agrees with the theory of favourable conditions promoting more residentially mobile groups, and tentatively fits with what we see in the south European record, in which populations appear to be more residentially mobile during the YD compared with the northwest. This interpretation of highly mobile populations in North America has been constructed through evidence of a high number of small, more ephemeral camps. However, LaBelle (2012) shows there are distinct site types in Folsom groups in the Plains and Rocky Mountains, and even evidence for structures. This evidence appears much more in line with more logistically mobile groups, especially when mountain basin camps were in drier, less favourable areas than nearby adjacent areas, and it seems unlikely they would have lived in these regions for long periods of time. If this is the case, then the response to more favourable conditions seems to be a shift to more logistically mobile strategies. However, in-depth analysis of available fauna seems to be limited in the American literature alongside artefact analyses, and the interactions of hunter-gatherer populations with hunted fauna is vital to understand choices in mobility behaviour. However, several papers (Anderson et al., 2011; LaBelle, 2012; Smallwood et al., 2015; Meeks and Anderson, 2011) suggest a distinct decrease in population at the onset of the YD, with a recovery in the latter half, or at the terminus and into the Holocene. This distinct decrease at the onset of the YD is widely seen across the Northern Hemisphere, but relies too heavily on radiocarbon dated remains which suffer from a variety of problems, such as sampling biases, radiocarbon dating contamination/inaccuracy, and preservation of organic material.

Whatever the mobility response type, it appears hunter-gatherers react more strongly to changes in precipitation and moisture in North America, which is supported by the evidence from northwest Europe. The European northwest climatic and environmental data suggests the first half of the YD was cold and dry, while the second was cold and wet. It was found in my earlier MPhil research (Andrews, 2012, unpublished MPhil thesis) that in the UK, Belgium, and the Netherlands, there was a distinct decrease in radiocarbon dated sites from the

Allerød into the first half of the YD, associated with drier conditions and the lowering of lake levels, and a notable increase in sites during the second half of the YD, which corresponds to wetter conditions and increasing lake levels. There was also evidence for decreases in site numbers that appear to coincide with drier conditions during the PBO, where again lake levels decreased. Unfortunately, due to inconsistent dating of the assemblages within my current research, sufficient sample sizes of sites allocated to the first and second half of the YD were not possible to collect. In many cases, the assemblages were loosely stratigraphically dated or pollen dated to the YD, or assigned by cultural association of projectile points, rather than directly radiocarbon dated. It is important for future research to attempt to reliably date assemblages to these phases of the YD to see if there are differences in mobility related to the changing levels of moisture within this period.

It is also important to understand the latitudinal location of the U.S. analyses to compare the European evidence. The Rocky Mountains region is around 44°N, the Southwest around 32°N-43°N, the Southeast around 30°N-41°N, and the Great Basin around 36°N-42°N. This is in comparison with the northwest European region of this study which is around 46°N-57°N, and the south region around 40°N-46°N. Therefore, it is evident the majority of North American analyses are of a lower latitude than even the south European assemblages from this study, and much lower than the northwest European assemblages.

7.8c - YD Research in Other Regions

Finally, key case studies from other regions in the Northern Hemisphere, outside of the Americas, will be presented and then discussed in terms of this study to further see the global understanding of the hunter-gatherer response to the YD.

The climate evidence from Japan (Nakazawa et al., 2011; Sato et al., 2011), China (Elston et al., 2011; Morgan, 2015), and Siberia and Eastern Russia (Buvit and Terry, 2011; Vasil'ev, 2011) show a distinct change in climate to a colder and drier climate during the YD. In Japan, this change brought about an increase in seasonality, with longer winters and shorter summers, decreased plant productivity, and decreased abundance of mammalian species (Nakazawa et al., 2011; Sato et al., 2011), and these changes, like that in the U.S., appear to correlate with a decrease in, or reorganisation of, human populations. Nakazawa et al., (2011) believe this decline in plant and mammalian species would have resulted in resources becoming patchy within the environment, and thus human populations would have changed their subsistence strategies to exploit resources within geographically dispersed patches located in a variety of environments, from lowland plains to highland mountains. Also, due to the mountainous terrain of Japan, they predict human populations would have favoured lower elevations during the colder conditions of the YD. However, they found little evidence from their results to support this, with no distinct changes in site locations, with high altitude sites still being occupied, although there is some evidence suggesting they did favour lower elevations. There was also no evidence of a change in latitude of sites, suggesting there was no southerly migration from the more mountainous regions in the north. This is similar to the European data, where there is no evidence of a southerly population migration by hunter-gatherer groups in northwest Europe. Nakazawa et al. (2011) do find evidence that the use of pottery, which begun in the Bølling-Allerød in Japan, was reduced in the YD, but the major change occurred in the PB where there is the first evidence for largescale pottery manufacture, suggesting this major shift occurred after the YD and not as a result. This again shows the major shifts in technology organisation occur within the Early Holocene and not as the result of the YD. Again, it should be noted Japan is roughly around 31°N-45°N, which is lower than most of the assemblages in the northwest and many of the south European datasets.

In northern China, Elston et al. (2011) predict, during the YD, there would have been a decrease in the broadening of the diet seen during the Allerød, along with a shift to higher level of mobility, related to declining primary (plant) productivity and an increase in steppe plant species. As in the Near East, in China, broadening of the diet and intensification has been linked with the origins of the shift from hunter-gatherer lifestyles to agriculture. However, their results found there was little change in plant-orientated intensification during the YD, and populations continued a lower mobility strategy and continued to focus on hunting, which would have ensured a higher return-rate in terms of energy. They found no compelling evidence there was any shift to a different mobility or subsistence strategy that could be related to the YD, and from this they (along with Morgan, 2015) believe the earliest date for the beginning of plant intensification, that would have led to agriculture, would have not occurred until after the YD, in the Early Holocene. It was only until the amelioration seen during the Early Holocene, that there was a notable increase in the abundance of plant species, and they believe this should have resulted in an increase in the growth rates of human populations, leading to broader diets, long-term plant-oriented intensification, and finally to agriculture. Again, there are distinct similarities to the south European data in which there is no major change in hunter-gatherer behaviour that can be linked to the YD, and it is the onset of the PB that seems to have had the greatest effect on human populations, in terms of settlement, subsistence, and technological organisation. Northern China is around 40°N-48°N, so the sites from this region are roughly equivalent in latitude to the south European dataset and the more northern areas of this region overlap with some of the assemblages from northwest Europe.

This apparent lack of a major response to the YD is also seen in Siberia and the Russian Far East. Buvit and Terry (2011) and Vasil'ev (2011) both found strong evidence for a continued and relatively dense occupation across the region. However, Vasil'ev (2011) shows there is a notable decrease in human population in all major areas of southern Siberia, and presumably over much of the region, and much like the records of most of the Northern Hemisphere. However, he found there was a continuation in the diversification of hunting practices that began in the Late Palaeolithic in Siberia, along with evidence for the appearance of aquatic exploitation, while Buvit and Terry (2011) highlight the continuation of microblade, biface, and burin lithic technologies, although new technologies such as harpoons, composite tools, and pottery emerged in some regions during this period, but elements of these technologies had appeared before the YD (Vasil'ev, 2011). This again shows there is little evidence for any major changes in technological organisation that can be related to the YD, but the apparent decease in population may have led to, or represent, a shift in settlement organisation, presumably to that of a more mobile strategy.

However, Buvit and Terry (2011), found the majority of evidence suggests there were no major behavioural shifts indicating stress occurred within human populations during the YD, and that before, and during the YD, settlements were almost exclusively located around river banks, where a variety of different resources could be exploited, possibly from seasonal base camps. This suggests a more logistical system was in place during both the Allerød and YD, and is supported by a few sites from both periods being associated with limited activity/special-task camps (Buvit and Terry, 2011). Buvit and Terry (2011) also found there are a small number of terminal Pleistocene sites in Siberia, potentially indicating, an increase in human sedentary lifestyles, with evidence for a focus on a few key plant and animal species, but, as with evidence from the above case studies, it appears many of these changes occurred prior to the YD, and again not as a result (Buvit and Terry, 2011). Siberia and the Russian Far East are around 60°N and so are significantly higher than the assemblages in the northwest European assemblages, but we still see evidence for little change in human behaviour from the Allerød to the YD. Also, it should be noted, in the particularly cold and dry climate of Siberia, it appears human populations were practising a more logistical strategy, one that is indicated from the results of this thesis during the YD in northwest Europe, and in agreement with the predictions made by Binford (1980).

Lastly, it is widely accepted the change in climate and environment during the YD in the Near East, facilitated the adoption of agriculture by forcing a shift to intensification due to subsistence stress (Bar-Yosef and Meadow, 1995; Zeder, 2011; Stiner et al., 2000). However, studies by Munro (2004 cited in Morgan, 2015) found the Early Natufian (12,800-11,000 cal BP) saw an increase in faunal diversity, with an increase in small animal exploitation, and more intensive carcass processing. In contrast, the Late Natufian (11,000-10,200 cal BP) saw an increase in the exploitation of larger fauna, which would have offered higher return-rates. She explains the cause of this shift is related to the decrease in human population density during the YD, and that shorter-term camps show an adaptation to increasing mobility during this period due to a decrease in animal and plant species, and increasing resource patchiness. Thus, she concludes the Late Natufian's, who are seen as the "antecedents to agriculture" (Morgan, 2015;172), were practising a subsistence strategy of decreasing diet breadth and an increasing level of mobility (Munro, 2004, cited in Morgan, 2015). This is very different from the theories of broader diet breadth and high intensification strategies that are often thought of as a precursor to agriculture (Morgan, 2015), and again shows that a major shift in mobility occurred within the PB, rather than the YD, in which there was an increase in behaviours that had already began in the Allerød, and potentially throws into question the YD's role in the adoption of agriculture.

7.8d - Summary of the YD in Other Regions

The studies in other regions around the globe all seem to generally indicate a pattern of non-response of hunter-gatherer populations to the YD. This is also concluded by Eren (2012), who believes there is currently little evidence for a connection between the YD and hunter-gatherer cultural change. There appears to be few studies that observe a significant change in mobility as result of the YD, and there is no strong evidence mobility significantly changed in south Europe from this study. However, this thesis has found such a change occurred in northwest Europe, in which it seems there was a distinctly greater contrast between the warm interstadials of the Allerød and PB and the YD, which offers one potential explanation regarding the results found in this study.

7.9 - Final Conclusions

This chapter has discussed the results of this study in terms of climatic and environmental change and changes in faunal species. These results and interpretations were then compared with other YD studies in northwest and south Europe, then to other regions in Europe, and finally with global studies into the YD. The main conclusions from this discussion are:

1. Mobility is not significantly affected by environmental change.
2. Mobility is affected by floral and faunal change, probably related to the levels of extreme conditions, such as permafrost, deep snow, and drought (as seen in northwest Europe).
3. The exact type of mobility is influenced by local/regional cultures/traditions/knowledge of what is considered the most efficient way to survive in certain conditions, and cannot be prescribed by climate/environmental/subsistence change.

The results of this study strongly suggest mobility changes are not significantly affected by changes in environment related to climate change, but are more affected by extreme conditions of climate, such as deep snowfall, permafrost, and lack of available moisture, which more severely affect the floral and faunal species (supported by Dolukhanov, 1996). The generalised environmental response appears to be remarkably similar between the northwest and the south European regions, with a marked drop in temperature (although not as severe in the south) and a dramatic opening of the landscape, but very different mobility responses were interpreted from their tool assemblages. The most significant difference between the regions was the severity of the conditions in terms of the presence of permafrost and the drying of the landscape, especially in the second half of the YD in the northwest. It should be noted that the geographical variability of the south may have had a part to play in providing localised areas of refugia, with more mountainous regions requiring a higher level of planning and scheduling of resource exploitation, but there has also been argued to be areas of refugia in the northwest (Coope and Joachim, 1980; Cordy, 1991; Terberger, 2004) and is not thought to be a major factor in the differences observed here.

It is theorised humans can survive in very harsh conditions, and climate change does not have a major effect on the choices of where human populations decide to live, rather the ability of floral and faunal species to survive affects how humans are organised in the landscape. In the south, the landscape opened to a more steppe-tundra, much as in the northwest, but the preferred large game species (red deer) continued to be present, although in a different environment. There is evidence of a slight shift to a more residential strategy during this phase, which might be a response to hunting the same animals in a different landscape. It could also be argued there is no real significant change in strategies from the Allerød to the YD, which would suggest environment had no effect on how they chose to hunt and forage, despite these dramatic changes. In the northwest, the harsher conditions meant a major shift in animal species. Red deer could no longer survive in the region, and reindeer and horse thrived. The behaviour of these species are very different, as red deer are a much more stationary species, while reindeer and horse are highly mobile. Thus, the mobility organisation of humans was determined by the available animal species. However, caution must be advised when assuming that past animal species behaved in similar ways to their modern analogues, an assumption that cannot be verified at present.

The PB is widely thought of as a period of amelioration after the harsh conditions of the YD, and would therefore be much more favourable for human populations. However, in the northwest, this does not appear to be the case according to the tool assemblage compositions. There is a more subdued return to a more residential strategy, which has more logistical components than the previous Allerød Interstadial, and there are many similarities to the YD. It is hypothesised the PBO cold and dry event, which occurred one or two centuries after the initial warming of the PB, interrupted the predicted return to the previous warm climate behaviour. There is no information on how this phase affected major game species, so the theory put forward here cannot be tested, but as this period lasted 200-300 years it may well have significantly affected animal population behaviours.

The PB in the south was dramatically different from both the Allerød and YD, with a notable increase in animal species and precipitation. During this period, there appears to be a preference for significantly more logistical mobility practices than during the Terminal Palaeolithic. This pronounced change in the tool assemblages is supported by many studies which show that the major changes in human behaviour appear to occur after the YD in south Europe. However, crucially, in the south it appears logistical mobility was the preferred response to increasing animal diversity and higher precipitation. In the northwest, more logistical strategies were preferred in the colder and harsher conditions of the YD, while more residential strategies were preferred during periods of increased animal diversity. Therefore, it could be argued the exact mobility response to changes in subsistence is related to cultural traditions/regional knowledge of the preferred response to an environmental/climatic/subsistence problem, and not to the types of flora and fauna available.

Another interesting result is that the composition of assemblages does not appear to significantly change depending on altitude, which is unexpected, but might support the view that humans can live in a variety of conditions unchanged, and dismisses the idea that high altitude sites are always special task camps. Site size/excavation area was also found not to be a factor in the composition of the tool assemblage, which also challenges the idea that smaller sites always have specialist functions.

If we look at global studies into the YD, we see a generalised picture of a continuation of hunter-gatherer populations from the Allerød into the YD, and there is no significant evidence to suggest there was a mass migration to warmer, more ‘favourable’ areas as a result of this event in any region, which is widely assumed to be the case with the previous LGM. Human populations continue to exist in regions they had become accustomed to over hundreds of generations and their response was to interact with new environments, and the flora and fauna contained within, in different ways which maximised efficiency. This can be seen from the results of this study, although there appears to be significant changes in mobility as a result of the YD in the harsher conditions of northwest Europe, most likely to efficiently exploit highly mobile reindeer and horse populations, which replaced the earlier, more stationary, red deer populations. The apparent finding here of a significant change to a more logistical strategy during the YD in northwest Europe seems to be unique in the global body of research, in which most regions report little change in hunter-gatherer behaviour in response to this event, including the south European data from this study. It is hypothesised here that northwest Europe experienced the most contrast in climate and environment from the Allerød into the YD, which may provide an explanation for this behaviour.

This study also adds to this picture, with the finding that, in Western Europe, the exact way in which they adapted to changes in their environment seems specific to regions, possibly to “cultural” groups, who had preconceived strategies learned from their predecessors as to which was the best way to organise their settlement and subsistence strategies according to the various conditions they faced. This is of course hypothetical, but the fact that during warmer times, with increased animal diversity of a similar set of species, northwest populations seemed to have utilised a more residentially mobile system, while in the south they utilised a more logistically mobile system, is cause to support this explanation.

Conclusions

This study aimed to answer questions regarding the climatic and environmental changes associated with the Pleistocene/Holocene Transition and hunter-gatherer mobility, by studying, analysing, and interpreting changes in their stone tool assemblages. This conclusion will address the key questions asked in order to assess how successful it was in determining changes in human mobility relating to the YD.

What is the predicted mobility behaviour of hunter-gatherer populations in warm climates and cold climates?

One of the most widespread theories used to model mobility changes is that of Binford (1980, 2001), who defines two types of hunter-gatherer mobility – logistical and residential – and this was the preferred model tested here due to its simplicity and ease of use, when drawing comparisons between climatic phases. In such a strategy, it is predicted by Binford (1980), in warmer climates, a more residential mobility would be employed, while in colder climates, a more logistical strategy would be employed. This is the assumption upon which the interpretations of this study are based, while acknowledging and accepting the flaws associated with this model. In northwest Europe, this theory is supported, as more residential strategies are recognised during the warm Allerød and PB Interstadials, compared with more logistical strategies during the cold YD Stadial. However, this is not seen in the south, where there were more logistically mobile populations during the PB Interstadial and possibly during the Allerød. There is some evidence to suggest there was a slight shift to a more residential strategy during the colder YD in this region, but there appears to be little change in behaviour between the Allerød and YD. However, the analysis shows some evidence that, in general, hunter-gatherer populations are more residentially mobile than those in the northwest. This suggests that Binford’s (1980) model only applies to hunter-gatherers in cold climates in higher latitude regions such as those of northwest Europe during the YD.

What was the extent of the climate and environmental changes in response to the YD in northwest and south Europe?

The climatic and environmental response to the YD was found to be remarkably similar between the northwest and south of Europe. Although there was a much more subdued decrease in temperature compared with the northwest, there is still evidence for a dramatic decline in temperatures with the onset of the YD in south Europe in many regions. This was accompanied as well, by a significant opening of the landscape to more steppe-tundra conditions. However, the conditions in the south were not severe enough to promote a major shift in game species, with red deer continuing to be the dominant species over much of the region, and reindeer were found to be absent in many regions in northern Spain and Italy. However, one possible factor of importance is that the more mountainous regions of the south may have offered areas of refugia, which may have influenced human choices in mobility in order to exploit them. In comparison, the YD in the northwest, brought about a complete change in the fauna, with the disappearance of red deer populations and the dominance of reindeer. However, although areas of refugia have been hypothesised in northwest Europe, one might believe they were less common/substantial than those found in the mountainous regions of northern Spain/southern France and Italy. This might be found to be a key factor in differences between northwest and south European hunter-gatherer behaviour, but cannot be determined within the constraints of this study.

Instead, it is believed here, the crucial difference between the two regions being that in the northwest, there is evidence for the existence of permafrost for large parts of the year during at least the initial phases of the YD, along with the significant drying of the landscape in the second-half of the stadial. This shows that although the general trend in climate and environment was similar between the northwest and south regions, the severity of conditions was much more extreme in the northwest. It is these extremes that no doubt brought about the disappearance of previously important game such as red deer, and the thriving of reindeer and horse in these environments, and in turn this change in game species would have brought about a shift in hunter-gatherer mobility strategies.

How can one predict potential changes in hunter-gatherer mobility in prehistory from the archaeological record? - and **- What indicators within hunter-gatherer stone tool assemblages are suitable for determining changes in mobility?**

Several theories and models were presented and discussed in Chapter 2, which informed that the best way to predict prehistoric hunter-gatherer mobility is through ideas related around cost, risk, and anticipation, and that the most suitable indicators within tool assemblages should focus upon tool diversity, tool expediency, and raw material exploitation. From this a list of predictions of stone tool indicators for mobility change were constructed, and further edited to form a suitable set of expectations based on the collected data for this study. After applying these expectations to the data, it was found that significant differences occurred within several of these indicators during the YD in the northwest of Europe, and that these indicators differed in the south. In the northwest, these differences were interpreted as evidence for a significant shift to a more logistical mobility from the Allerød into the YD, and a similar, but more subdued shift back to a more residentially mobile strategy during the PB. The differences between the northwest and south imply there was a different and more subdued response to the YD in south Europe, as one might expect. The results of the southern data strongly correlate with the majority of current research, in that there was a more subdued response to the YD, with human behavioural continuity from the Allerød into the YD, and a major shift in behaviour only occurred during the PB. As this correlation was found, it is proposed that the set of stone tool assemblage expectations formulated within this study are suitable for identifying mobility change, and as such correctly detects a major shift in mobility practices in the northwest during the YD, and in the south during the PB.

How do hunter-gatherer populations respond in terms of mobility interpreted using stone tool indicators to the YD event in northwest Europe?

The results of the stone tool assemblage indicator analyses strongly suggest there was a significant shift in the composition of hunter-gatherer tool assemblages into and out of the YD in northwest Europe. This shift has been interpreted as a change from a more residential strategy during the Allerød, to a more logistical strategy during the YD, and back to a more residential strategy during the PB. Interestingly, there is a more subdued return to a residential strategy during the PB, suggesting that conditions were not as favourable as the Allerød, and may be due to the more pronounced effect of the PBO in the northwest soon after the initial warming phase of the Holocene. Overall, it appears that human populations in the northwest did respond in terms of mobility not only to the YD stadial, but also possibly to the PBO event during the PB.

To what extent do hunter-gatherer populations respond differently in lower latitudes in south Europe, where the effects of the YD were less pronounced?

As expected, there is strong evidence of a different mobility response in the south compared with the northwest. It appears that there was no major change in mobility from the Allerød into the YD, and that there was a significant shift to a more logistical strategy during the PB. Human populations appear to be generally more residentially mobile throughout the study period in the south, which agrees with Binford's (1980) prediction that hunter-gatherers in warmer regions should practise a more residential mobility. Interestingly, in contrast to the northwest, there is also a continuity in faunal species from the Allerød to the YD, which one would expect not to be a coincidence with the lack of major changes in human behaviour during this period. It is only in the PB, where there is a significant increase in the diversity of fauna, do we see a dramatic change in mobility. Therefore, it is thought that hunter-gatherer populations are minimally influenced by changes in temperature and environment, and that the change to a more logistical system seen in the northwest should be seen as a response to changing animal populations, which are in turn only affected by extremes of climatic and environmental change.

How do hunter-gatherer populations respond to the YD event globally, based on current research? – and – **Do the results of this study agree or disagree with this current knowledge?**

Global studies, outlined in Chapter 7, provide no strong evidence that there was a major change in human behaviour in response to the YD, and that most of the significant changes occur within the early Holocene. In general, there is more evidence for continuity in human populations than behaviour shifts (Eren, 2012). This is further supported from the results of the southern comparative database from this study, which also sees no strong evidence for a change in human mobility between the Allerød and YD, and a significant shift during the PB. However, few detailed studies have been carried out in the northwest of Europe focusing on mobility change in response to the YD. This study has found that there may well have been a distinct shift in human mobility that can be related to the YD Stadial event in the northwest, and thus disagrees that this behavioural consistency is universal. It is thought, that northwest Europe is unique in regard to many other regions in which YD research has been conducted. Seemingly, this region displays the largest contrast in climatic conditions between the Allerød and YD, and the YD and PB. Few other regions see a shift from Allerød conditions that are similar to that of today, to extreme YD conditions of seasonal, and in some areas continuous, permafrost, along with significant drying out of the landscape, and then returning to Allerød-like conditions into the PB. It is this extreme contrast, along with the significant change that it facilitated in animal populations, that we see evidence for a distinct shift in human behaviour during the YD in northwest Europe.

How do the results of this study build upon the current knowledge of hunter-gatherer responses to major climatic changes?

This study adds to the general picture of robust human populations continuing to persist in the face of significant climatic change. However, unlike the majority of global research, which sees little evidence for behaviour change during the YD, it appears that in northwest Europe, there is evidence that the more extreme and contrasting conditions seen during this period brought about a distinct shift in mobility, from a more residential system during the Allerød, to a more logistical mobility during the YD. Interestingly, the results of the south European data analysis agree with most other global studies, in that there is strong evidence for behavioural continuity between the Allerød and YD, with the major shift in behaviours occurring during the PB. This lends further support that the changes we see using the methods of analysis used in this study in the northwest of Europe are genuine, and can be relied upon.

Another interesting finding from this study, is that there is evidence suggesting the exact type of mobility change – more logistical or more residential – is not a prescribed behaviour dictated by climatic/environmental/subsistence stress, and can differ in nature from region to region depending upon the more regional cultural history/knowledge of local populations.

A note on problems with multi-region analysis and comparisons and future work

While conducting this study, data was collected from a wide range of regions, encompassing twelve different countries. Few studies have collected and interpreted detailed tool assemblage data from this many countries, and provides an interesting opportunity to briefly discuss the problems associated with the regulation (or lack of) research practice and traditions within tool assemblage studies.

Several problems were encountered, not least the difficulties in non-standardised definitions of tool types and functions. For example, reported assemblages from some countries have dozens of recognised burin types, each of which is assumed to function differently, while others simply classify this tool type as a single category of "burins". This variation not only happens between regions and countries, but also within countries too, and is not only limited to burins. To categorise tools by slight morphological changes seems to be overcomplicating matters when analysing an assemblage and, when attempting to determine tool diversity, can be a major causation of misinterpretation if not addressed.

Similarly, with projectiles (if one assumes the function of these morphological types are in fact projectiles); how different in functionality is one projectile point from another? It serves the purpose of hunting, that is, effectively to efficiently kill an animal for food. Obviously, the range of uses of a point/s can provide us with vital information on subsistence strategies i.e. points to kill large-mid-sized ungulates, points to kill fish, points to kill birds etc., along with changes in complexity, i.e. composite points, which are seen as a risk minimising strategy. However, these differences in function can only be reliably recognised through detailed information on aspects of manufacture such as hafting. This is rarely published in sufficient detail in the data. Instead, what is focused upon, is morphological differences related to supposed different regional cultures and traditions, both temporally and spatially. This has no use when attempting to ascertain the richness and evenness of a stone tool assemblage. Until there is regulation and publication of distinct, functionally different point types, based on evidence such as hafting, this issue cannot be addressed. Tool studies should focus away from “cultural” groups (if you can truly recognise cultural groups from tools alone) and focus on more substantial behavioural changes such as that evidenced from generalisation/specialisation and risk management of toolkits.

This varied reporting of tool categories led to the simplified categories utilised in this study. This decision may lead to the masking of true functional variation between and within different tool categories, but is deemed a more reliable way in which to approach toolkit diversity, as the alternative is currently too subjective.

Also, more robust reporting of tool assemblages must be published within reports. Average size of tool elements, numbers of chips, types and numbers of preparation pieces, retouched and utilised blanks, hafting information on points, distance of raw material provenance from sites, percentage of different quality materials, weight of raw materials, altitude, excavation size and size of “sites”, and density/volume of artefacts are vital to be able to make more reliable observations, but are all variably published, and often not sufficiently reported, if at all. This variability of reporting led to many of the potential indicators being unsuitable and unreliable for this study, due to small sample sizes of comparable sites. To observe changes in tool technology relating to climate change, it is imperative to have globally (or at least continentally) regulated definitions of functionally different tool types that can allow the direct comparison of assemblages from the global perspective all the way down to the local level, along with facilitating the collection of larger datasets from several regions when sample sizes are low.

It should always be noted that categorising a tool into specific type will always be subjective, and ultimately may be an incorrect practice, but an agreement must be made to universally report assemblages to the same standard to allow these more direct comparisons. It is believed here that this practice, in the current research climate, would gain more than it would mask.

However, despite these issues, this study has proved, by analysing and comparing the characteristics of stone tool assemblage inventories from a large database of sites from a region, and applying the results to a robust theoretical framework, it is possible to gain important information on shifts (or lack of shifts) in hunter-gatherer mobility in response to climatic and environmental change. To further the results of this study, future work should be expanded to cover different regions, such as North America, and to include different major climate events, such as the LGM and 8.2kya event. Additionally, further studies should focus upon other aspects of hunter-gatherer behaviour within a modified version of the theoretical framework proposed in this study, such as direct comparisons of human exploited faunal assemblages from multiple sites within different regions with unique environmental signals and geographic topography (such as Cantabrian Spain, Mediterranean Spain, southern France, pre-Alps Italy, and non-alpine Italy to name a few in Europe) to see if distinct patterns of specialised and generalised behaviour can be detected. There is a large and ever-increasing number of well documented sites from many different climatic and environmental episodes across the world, from whose detailed and varied archaeological information should be collected into larger, regional, databases and compared with other regions against a theoretical methodology, constructed in a similar fashion to this study. Through this, I believe, a more robust picture of the variety of global human responses to different climatic and environmental changes in different geographic regions can be achieved.

References

Adler, D. S., Bar-Oz, G., Belfer-Cohen, A., Bar-Yosef, O., (2006), Ahead of the game: Middle and Upper Palaeolithic hunting behaviors in the Southern Caucasus, *Cultural Anthropology*, Vol. 47:1, pp. 89-118.

Aldenderfer, M., (2006), Modelling plateau peoples: The early human use of the world's high plateaux, *World Archaeology*, Vol. 38:3, pp. 357-370.

Altuna, J., Mariezkurrena, K., (1996), Faunes de mammifères des gisements magdaléniens du Pays basque et zones limitrophes, in: Delporte, H., Clottes, J. (Eds.), Pyrénées préhistoriques, arts et sociétés, 118e Congres du CTHS, Pau, 1993. Ed. du Comité des Travaux Historiques et Scientifiques, Paris, pp. 149-162.

Ammerman, A. J., Feldman, M. W., (1974), On the "making" of an assemblage of stone tools, *American Antiquity*, Vol. 39, pp. 610-616.

Anderson, D. G., Goodyear, A. C., Kennett, J., West, A., (2011), Multiple lines of evidence for possible Human population decline/settlement reorganization during the early Younger Dryas, *Quaternary International*, Vol. 242, pp. 570-583.

Andrefsky, W., (1994), Raw-Material availability and the organization of technology, *American Antiquity*, Vol. 5: 9(1), pp. 21-34.

Andrefsky, W., (1998), Lithics: Macroscopic Approaches to Analysis, 2nd Edition, Cambridge University Press.

Andrefsky, W., (2008), Projectile point provisioning strategies and human land-use. In Andrefsky, W., (eds.), Lithic Technology: Measures of Production, Use and Curation, Cambridge University Press, pp. 195-216.

Andrefsky, W., (2009), The Analysis of Stone Tool Procurement, Production, and Maintenance, *Journal of Archaeological Research*, Vol. 17, pp. 65-103.

Andrews, C. J., (2011), Are there changes in human settlement patterns through the terminal Pleistocene/Hlocene boundary from ca. 13,700-10,800 cal. BP in the UK and the Low Countries, and is there a correlation with climate and environment associated with the Younger Dryas? Unpublished MPhil Thesis, Department of Archaeology, University of Cambridge.

Aura, J. E., Jordá, J. F., Montes, L., Utrilla, P., (2011), Human responses to Younger Dryas in the Ebro valley and Mediterranean watershed (Eastern Spain), *Quaternary International*, Vol. 242, pp. 348-359.

Ballenger, J. A. M., Holliday, V. T., Kowler, A. L., Reitze, W. T., Prasciunas, M. M., Miller, D. S., Windingstad, J. D., (2011), Evidence for Younger Dryas global climate oscillation and human response in the American Southwest, *Quaternary International*, Vol. 242, pp. 502-519.

Bamforth, D. B., (1986), Technological efficiency and tool curation, *American Antiquity*, Vol. 51:1, pp. 38-50.

Banks, W.E., d'Errico, F., Zilhão, J., (2013), Human-climate interaction during the Early Upper Paleolithic: Testing the hypothesis of an adaptive shift between the Proto-Aurignacian and the Early Aurignacian, *Journal of Human Evolution*, 64:1, pp. 39-55.

Barbaza, M., (2011), Environmental changes and cultural dynamics along the northern slope of the Pyrenees during the Younger Dryas, *Quaternary International*, Vol. 242, pp. 313-327.

Barton, N., (1991), Technological innovation and continuity at the end of the Pleistocene in Britain, in Barton, N., Roberts, A. J., Roe, D. A, (Eds.), The Late Glacial in north-west Europe: Human adaptation and environmental change at the end of the Pleistocene, CBA Research Report, No. 77, Council for British Archaeology, pp. 234-245.

Barton, L., Brantingham, P. J., (2007), Late Pleistocene climate change and Paleolithic cultural evolution in northern China: Implications from the Last Glacial Maximum, *Developments in Quaternary Sciences*, Vol. 9, pp. 105-128.

Barton, N., (1999), The Lateglacial or Late and Final Palaeolithic Colonization of Britain, in Hunter, J., Ralston, I., (Eds.), The Archaeology of Britain: An introduction from the Upper Palaeolithic to the Industrial Revolution, Routledge, London, pp. 13-34.

Bar-Yosef, O., Meadow, R. H., (1995), The origins of agriculture in the Near East, in Price, T. D., Gebauer, A. B., (Eds.), Last hunters, first farmers: new perspectives on the prehistoric transition to agriculture, Santa Fe, NM: School of American Research Press, pp. 39-94.

Bedford, A., Jones, R. T., Lang, B., Brooks, S. J. and Marshall, J. D., (2004), A late-glacial chironomid record from Hawes Water, northwest England, *Journal of Quaternary Science*, Vol. 19, pp. 281-90.

Bignon, O., Eisenmann, V., (2002), Western European Late Glacial horse diversity and itsecological implications, in Mashkour, M., (Eds.), Equids in Time and Space, 9th ICAZ Conference, Durham 2002, pp. 161-171.

Binford, L. R. (1968), Post-Pleistocene adaptations, in: Binford, S. R., Binford, L. R., (Eds.), New Perspectives in Archaeology, Aldine, Chicago, pp. 313-341.

Binford, L. R., (1973), Interassemblage variability: The Mousterian and the "Functional" argument, in Renfrew, C., (eds.), The explanation of culture change, *Duckworth*, London, pp. 227-254.

Binford, L. R., (1976), Forty-seven trips: A case study in the character of some formation processes of the archaeological record, in Hall, E. S., (Eds.), Contributions to Anthropology: The Interior of Peoples of Northern Alaska, National Museum of Man, Mercury Series Paper No. 49, Ottawa, pp. 299-351.

Binford, L. R., (1977), Forty-seven trips, in Wright, R. V. S., (Eds.), Stone tools as cultural markers, Australian Institute of Aboriginal Studies, Canberra, pp. 24-36.

Binford, L. R., (1979), Organization and formation processes: Looking at curated technologies, *Journal of Anthropological Research*, Vol. 35, pp. 255-273.

Binford, L. R., (1980), Willow smoke and dog's tails; hunter-gatherer settlement systems and archaeological site formation, *American Antiquity*, Vol. 45, pp. 4-20.

Binford, L. R., (2001), Constructing frames of reference: An analytical method for archaeological theory building using hunter-gatherer and environmental datasets. *University of California Press*, Berkeley.

Birdsell, J., (1958), On population structure in generalised hunting and collecting populations, *Evolution*, Vol. 12, pp. 189-205.

Blades, B. S., (1999), Aurignacian lithic economy and early modem human mobility: New perspectives from classic sites in the Vezre Valley of France, *Journal of Human Evolution*, Vol. 37, pp. 91-120.

Blades, B. S., (2003), End scraper reduction and hunter-gatherer mobility, *American Antiquity*, Vol. 68:1, pp. 141-156.

Bleed, P., (1986), The optimal design of hunting weapons: Maintainability or reliability, *American Antiquity*, Vol. 51:4, pp. 737-747.

Boesch, C., Boesch, H., (1984), Mental map in wild chimpanzees: An analysis of hammer transports for nut cracking, *Primates*, Vol. 25, pp. 160-170.

Bohncke, S. J. P., (1993), Lateglacial environmental changes in the Netherlands: Spatial and temporal patterns, *Quaternary Science Reviews*, Vol. 12, pp. 707-717.

Bousman, C. B., (1993), Hunter-gatherer adaptations, economic risk and tool design, *Lithic Technology*, Vol. 18:1/2, pp. 59-86.

Brantingham, P. J., (2003), A neutral model of stone raw material procurement, *American Antiquity*, Vol. 68, pp. 487-509.

Brantingham, P. J., Ma, H., Olsen, J. W., Gao, X., Madsen, D. B., Rhode, D. E., (2003), Speculation on the timing and nature of Late Pleistocene hunter-gatherer colonization of the Tibetan Plateau, *Chinese Science Bulletin*, Vol. 48:14, pp. 1510-1516.

Bridault, A., Chaix, L., Pion, G., Oberlin, C., Thiebault, S., Argant, J., (2000), Position chronologique du renne (Rangifer tarandus L.,) à la fin du Tardiglaciaire dans les Alpes du Nord françaises et le Jura meridional, in Pion, G., (Eds.), Le Paléolithique supérieur récent: nouvelles données sur le peuplement et I'environnement, Table ronde de Chambéry, 1999, t. 28. Mem. SPF, pp. 47-57.

Bridault, A., Fontana, L., (2003), Enregistrement des variations environnementales par les faunes chassées, dans les zones de moyenne montagne d'Europe occidentale, au Tardiglaciaire et au début de 1'Holocene, in Patou-Mathis, M., Bocherens, H., (Eds.), Le rôle de l’environnement dans les comportements des chasseurs-cueilleurs préhistoriques, Colloque 3.1, actes du XIVe Congres UISPP, Liége, 2001. BAR 1105, pp. 55-65.

Brooks, S. J., (2006), Fossil midges (Diptera: Chironomidae) as palaeoclimatic indicators for the Eurasian region, *Quaternary Science Reviews*, Vol. 25, pp. 1894-1910.

Brooks, S. J., Mayle, F. E., Lowe, J. J., (1997), Chironomid-based Lateglacial climatic reconstruction for southeast Scotland, *Journal of Quaternary Science*, Vol. 12:2, pp. 161-167.

Brooks, S. J., Birks, H. J. B., (2001), Chironomid-inferred air temperatures from Lateglacial and Holocene sites in north-west Europe: progress and problems, *Quaternary Science Reviews*, Vol. 20, pp. 1723-1741.

Brooks, S.J., Birks, H. J. B., (2000), Chironomid-inferred Late-glacial air temperatures at Whitrig Bog, southeast Scotland, *Journal of Quaternary Science*, Vol. 15:8, pp. 759-764.

Buvit, I., Terry, K., (2011), The twilight of Paleolithic Siberia: Humans and their environments east of Lake Baikal at the late-glacial/Holocene transition, *Quaternary International*, Vol. 242, pp. 379-400.

Calvin, W. H., (2002), A Brain for All Seasons: Human Evolution and Abrupt Climate Change, University of Chicago Press.

Charnov, E. L., (1976), Optimal foraging and the marginal value theorem. *Theoretical Population Biology*, Vol. 9, pp. 129-136.

Clarke, J. G. D., (1954), Excavations at Star Carr, Cambridge University Press.

Clarke, J. G. D., Kurishima, H., (1979), Hominid occupation of the East-Central Highlands of Ethiopia in the Plio-Pleistocene, *Nature*, Vol. 282, pp. 33-39.

Close, A. E., (1996), Carry that weight: The use and transportation of stone tools*, Current Anthropology*, Vol. 37: 3, pp. 545-553.

Collard, M., Kemery, M., Banks, S., (2005), Causes of toolkit variation among hunter-gatherers: A test of four competing hypotheses, *Canadian Journal of Archaeology*, Vol. 29:1, pp. 1-19.

Coope, G. R., Brophy, J. A. (1972), Late Glacial environment changes interpreted by a Coleoptera succession from North Wales, *Boreas*, Vol. 1, pp. 97-142.

Coope, G. R., Joachim, M. J., (1980), Lateglacial environment changes interpreted from fossil Coleoptera from St Bees, Cumbria, N. W. England, In Lowe, J.J., Gray, J.M., Robinson, J. E. (Eds.), Studies in the Lateglacial of north-west Europe, pp. 55-68. Oxford, Pergamon Press.

Coope, G. R., Lemdahl, G., Lowe, J. J., Walking, A., (1998), Temperature gradients in northern Europe during the last glacial-Holocene transition (14-9 ^{14}C kya BP) interpreted from coleopteran assemblages, *Journal of Quaternary Science*, Vol. 13:5, pp. 419-433.

Cordy, J. M., (1991), Palaeoecology of the Late Glacial and early Postglacial of Belgium and neighbouring areas, in Barton, N., Roberts, A. J., Roe, D. A., (Eds.), (1991), The Late Glacial of Northwest Europe: Human adaptation and environmental change at the end of the Pleistocene, CBA Research Reports No. 77, pp. 40-47.

Cowan, L. F., (1999), Making Sense of Flake Scatters: Lithic Technological Strategies and Mobility, *American Antiquity*, Vol. 64:4, pp. 593-607.

Crombé, P., Sergant, J., Robinson, E., De Reu, J., (2011), Hunter-gatherer responses to environmental change during the Pleistocene-Holocene transition in the southern North Sea basin: Final Palaeolithic-Final Mesolithic land use in northwest Belgium, *Journal of Anthropological Archaeology*, Vol. 30, pp. 454-471.

Crombé, P., Sergant, J., Verbrugge, A., De Graeve, A., Cherrette, B., Mikkelsen, J., Cnudde, V., De Kock, T., Huisman, H. D. J., van Os, B. J. H., Van Strydonck, M., Boudin, M., (2014), A sealed flint knapping site from the Younger Dryas in the Scheldt valley (Belgium): Bridging the gap in human occupation at the Pleistocene-Holocene transition in W Europe, *Journal of Archaeological Science*, Vol. 50, 420-439.

Crombé, P., Verbruggen, C., (2002), The Lateglacial and early postglacial occupation of northern Belgium: the evidence from Sandy Flanders, In Eriksen, B.V., Bratlund, B. (Eds.) Recent studies in the Final Palaeolithic of the European Plain, Højbjerg, *Jutland Archaeological Society*, pp. 204-219.

Cruz-Uribe, K., (1988), The use and meaning of species diversity and richness in archaeological faunas, *Journal of Archaeological Science*, Vol. 15, 179-196.

Davis, B. A. S., Brewer, S., Stevenson, A. C., Guiot, J., (2003), The temperature of Europe during the Holocene reconstructed from pollen data, *Quaternary Science Reviews*, Vol. 22, pp. 1701-1716.

Debout, G., Olive, M., Bignon, O., Bodu, P., Chehmana, L., Valentin, B., (2012), The Magdalenian in the Paris Basin: New results, *Quaternary International*, Vol. 272-273, pp. 176-190.

Deeben, J., Schreurs, J., (2012), The Pope, a miracle and an Ahrensburgian windbreak in the municipality of Waalre (province of Noord-Brabant), the Netherlands, in: Niekus. M. J. L. Th., Barton, R. N.E., Street, M., Terberger, Th., (Eds.), A mind set on flint. Studies in honour of Dick Stapert, Barkhuis, pp. 295-320.

deMenocal, P. B., (2011), Climate and evolution, *Science*, Vol. 331:6017, pp. 540-542,

Dolukhanov, P. M., (1996), The Pleistocene-Holocene Transition on the East European Plain, in: Straus, L. G., Eriksen, B. V., Erlandson, J. M., Yesner, D. R., (Eds.), Humans at the end of the Ice Age: The archaeology of the Pliestocene-Holocene Transition, Interdisciplinary Contributions to Archaeology, Plenum Press, New York and London, pp. 159-170.

Drucker, D. G., Rosendahl, W., Van Neer, W., Weber, M. J., Görner, I., Bocherens, H., (2016), Environment and subsistence in north-western Europe during the Younger Dryas: An isotopic study of the human of Rhünda (Germany), *Journal of Archaeological Science*: *Reports 6*, pp. 690-699.

Dupré, M., (1988), Palinología y Paleoambiente: Nuevos Datos Españoles, in Estévez, J., (2005), Trabajos Varios, Vol. 84, Servicio de Investigación Prehistórica, Valencia, Catástrofes en Prehistoria, Bellaterra, Barcelona.

Durham, W. H., (1981), Overview: Optimal foraging analysis in human ecology, in Winterhalder, B., Smith, E. A., (Eds.), Hunter-gatherer foraging strategies, Ethnographic and archeological analyses, The University of Chicago Press, Chicago, pp. 218-231.

Elston, R. G., Guanghui, D., Dongju, Z., (2011), Late Pleistocene intensification technologies in Northern China, *Quaternary International*, Vol. 242, 401-415.

Eren, M. I., (2012), On Younger Dryas climate change as a causal determinate of prehistoric hunter-gatherer culture change, in Eren. M. I., (Eds.), Hunter-gatherer behavior: Human response during the Younger Dryas, Left Coast Press, pp. 11-24.

Eriksen, B. V., (1996), Resource Exploitation, Subsistence Strategies, and Adaptiveness in Late Pleistocene-Early Holocene Northwest Europe, in: Straus, L. G., Eriksen, B. V., Erlandson, J., Yesner, D. R., (Eds.), Humans at the end of the Ice Age: The archaeology of the Pliestocene-Holocene Transition, Interdisciplinary Contributions to Archaeology, Plenum Press, New York and London, pp. 101-128.

Froom, R., (2005), Late Glacial Long Bad sites in the Kennet Valley: Excavations and fieldwork at Avington VI, Wawcott XII and Crown Acres, The British Museum Research Publication Number 153, The British Museum.

Gamble, C., (1993), Timewalkers. The Prehistory of Global Colonization. Penguin, London.

Gamble, C., Davies, W., Pettitt, P., Richards, M., (2004), Climate change and evolving human diversity in Europe during the last glacial, *Philosophical Transactions of the Royal Society*, Vol. 359, pp. 243-254.

Gandouin, E., Franquet, E., Van Vliet-Lanoë, B., (2005), Chironomids (Diptera) in river floodplains: their status and potential use for palaeoenvironmental reconstruction purposes, *Archiv für Hydrobiologie*, Vol. 162, pp. 511-34.

Gandouin, E., Ponel, P., Franquet, E., Van Vliet-Lanoë, B., Andrieu-Ponel, V., Keen, D. H., Brulhet, J., Brocandel, M., (2007), Chironomid responses (Insect: Diptera) to Younger Dryas and Holocene environmental changes in a river floodplain from northern France (St-Momelin, St-Omer basin), *The Holocene*, Vol. 17:3, pp. 331-347.

Gandouin, E., Rioual, P., Pailles, C., Brooks, S. J., Ponel, P., Guiter, F., Djamali, M., Andrieu-Ponel, V., Birks, H. J. B., Leydet, M. and Belkacem, D., (2016), Environmental and climate reconstruction of the late-glacial-Holocene transition from a lake sediment sequence in Aubrac, French Massif Central: Chironomid and diatom evidence, *Palaeogeography, Palaeoclimatology, Palaeoecology*, Vol. 461, pp. 292-309.

García Codrón, J. C., (1996), Un clima para la historia… una historia para el clima. Santander: Servicio de Publicaciones de la Universidad de Cantabria.

García Moreno, A., (2007), La evolución del paisaje en la transición al Holoceno Desarrollo de un modelo predictivo de vegetación en el Valle del Asón (Cantabria), *Trabajos de Prehistoria*, Vol. 64:2, pp. 55-71.

Garcia-Guixe, E., Martinez-Moreno, J., Mora, R., Nunez, M., Richards, M. P., (2009), Stable isotope analysis of human and animal remains from the Late Upper Palaeolithic site of Balma Guilanya, southeastern Pre-Pyrenees, Spain, *Journal of Archaeological Science*, Vol. 36, pp. 1018-1026

Goebel, T., Hockett, B., Adams, D. K., Rhode, D., Graf, K., (2011), Climate, environment, and humans in North America's Great Basin during the Younger Dryas, 12,900-11,600 calendar years ago, *Quaternary International*, Vol. 242, pp. 479-501.

Gould, R. A., (1980), Living archaeology, *Cambridge University Press*, Cambridge.

Greaves, R. D., (1997) Hunting and multifunctional use of bows and arrows: Ethnoarchaeology of technological organization among Pume hunters of Venezuela, in Knecht, H., (Eds.), Projectile technology, Plenum Press, New York, pp. 287-320.

Heiri, O., Cremer, H., Engels, S., Hoek, W. Z., Peeters, W., Lotter, A. F., (2007), Lateglacial summer temperatures in the northwest European lowlands: A chironomid record from Hijkermeer, the Netherlands, *Quaternary Science Reviews*, Vol. 26, pp. 2420-2437.

Hetherington, R., Reid, R. G. B., (2010), The Climate Connection: Climate Change and Modern Human Evolution, Cambridge University Press, New York.

Hoek, W. Z., (1997), Late-glacial and early Holocene climatic events and chronology of vegetation development in the Netherlands, *Vegetation History and Archaeobotany*, Vol. 6, pp. 197-213.

Hoek, W. Z., Bohncke, S. J. P., Ganssen, G. M. & Meijer, T., (1999), Lateglacial environmental changes recorded in calcareous gyttja deposits at Gulickshof, southern Netherlands, *Boreas*, Vol. 28, pp. 416-432.

Hoek, W. Z., Bohncke, S. J. P., (2002), Climatic and environmental events over the Last Termination, as recorded from The Netherlands: A review, *Netherlands Journal of Geosciences*, Vol. 81:1, pp. 123-137.

Hublin, J.J., Roebroeks, W., (2009), Ebb and flow or regional extinctions? On the character of Neandertal occupation of northern environments, *Comptes Rendus Palevol*, Vol. 8:5, pp. 503-509.

Hunt, T. G., Birks, H. J. B., (1982), Devensian Late-glacial vegetational history at Sea Mere, Norfolk, *Journal of Biogeography*, Vol. 9, pp. 517-538.

Innes, J. B., Rutherford, M. M., O'Brien, C. E., Bridgland, D. R., Mitchell W. A., Long A. J., (2009), Late Devensian environments in the Vale of Mowbray, North Yorkshire, UK: evidence from palynology, *Proceedings of the Geologists' Association*, Vol. 120:4, pp. 199-208.

Iriarte, M.J., (2008), El paisaje vegetal del Abrigo de Portugain (Sierra de Urbasa, Navarra) durante el final del último ciclo glaciar, in Barandiarán, I., Cava, A., (Eds.), Cazadores y Tallistas en el Abrigo de Portugain, Fundación José Miguel de Barandiarán, Ataun, pp. 205-217.

Isarin, R. F. B., Renssen, H., Vandenberghe, J., (1998), The impact of the North Atlantic Ocean on the Younger Dryas climate in northwestern and central Europe, *Journal of Quaternary Science*, Vol. 13, pp. 447-453.

Isarin, R. F. B., Bohncke, S. J. P., (1999), Mean July Temperatures during the Younger Dryas in Northwestern and Central Europe as Inferred from Climate Indicator Plant Species, *Quaternary Research*, Vol. 51, pp. 158-173.

Jacquier, J., (2014), Analyse fonctionnelle des outillages lithiques et interprétations socio-économique du statut des sites tardiglaciaires du Buhot à Calleville (Eure) et de la Fosse à Villiers-Charlemagne (Mayenne), in: Langlais, M, Naudinot, N., Peresani, M., (Eds.), Les groupes culturels de la transition Pléistocène-Holocène entre Atlantique et Adriatique Actes de la séance de la Société préhistorique française de Bordeaux, 24-25 mai 2012, pp. 221-246.

Jeske, R., (1989), Economies in raw material use by prehistoric hunter-gatherers, in Torrence, R., (Eds.), Time, energy and stone tools, New Directions in Archaeology, Cambridge University Press, pp. 34-45.

Jochim, M. A., (1976), Hunter-gatherer Subsistence and Settlement: A Predictive Model, Academic Press Inc.

Jochim, M. A., (1983), Optimization Models in Context, in Archaeological Hammers and Theories, Moore J. A., Keene, A. S., (Eds.), Academic Press, New York, pp. 157-172.

Jochim, M. A., (1988) Optimal Foraging and the Division of Labor, *American Anthropologist*, Vol. 90, pp. 130-136.

Jochim, M. A., (1989), Optimisation and stone tool studies: Problems and potentials, in Torrence, R., (Eds.), Time, energy and stone tools, Cambridge University Press, pp. 106-111.

Jones, E. L., (2009), Climate change, patch choice, and intensification at Pont d'Ambon (Dordogne, France) during the Younger Dryas, *Quaternary Research*, Vol. 72:3, pp. 371-376.

Jones, E. L., (2016), In Search of the Broad Spectrum Revolution in Paleolithic Southwest Europe, SpringerBriefs in Archaeology.

Jones, G. T., Beck, C., Grayson, D. K., (1989), Measures of diversity and expedient lithic technologies, in Leonard, R. D., Jones, G. T., (Eds.), Quantifying diversity in archaeology, Cambridge University Press, pp. 69-78.

Jones, R. T., Marshall, J. D., Crowley, S. F., Bedford, A., Richardson, N., Bloemendal, J., Oldfield, F., (2002), A high resolution, multiproxy Late-glacial record of climate change and intrasystem responses in northwest England, *Journal of Quaternary Science*, Vol. 17:4, pp. 329-340.

Kaplan, K. H., Hill, K., (1992), The evolutionary ecology of food acquisition, in Smith, E. A., Winterhalder, B., (Eds.), Evolutionary ecology and human behavior, *Aldine de Gruyter*, New York, pp. 167-201 .

Keeley, L. H., (1982), Hafting and retooling: Effects on the archaeological record, *American Antiquity*, Vol. 47, pp. 798-809.

Kelly, R. L., (1983), Hunter-gatherer mobility strategies, *Journal of Anthropological Research*, Vol. 39, pp. 277-306.

Kelly, R. L., (1995), The Foraging Spectrum: Diversity in Hunter-Gatherer Lifeways, Smithsonian Institution Press, Washington D.C.

Kelly, R.L., Todd, L. C., (1988), Coming into the country: Early Paleoindian hunting and mobility, *American Antiquity*, Vol. 5:3(2), pp. 231-44.

Kent, S., (1991), The relationship between mobility strategies and site structure, in Kroll, E., Price, T. D., (Eds.), The Interpretation of spatial patterning within Stone Age archaeological sites, Plenum, New York, pp. 33-59.

Kent, S., (1992), Studying variability in the archaeological record: An ethnographical model for distinguishing mobility patterns, *American Antiquity*, Vol. 57: 4, pp. 635-660.

Kent, S., Vierich, H., (1989), The myth of ecological determinism: Anticipated mobility and site Spatial organization, in Kent, S., (Eds.), Farmers as hunters: Implications of sedentism, Cambridge University Press, Cambridge, pp. 96-134.

Klerk, P., (2004), Changes in vegetation and environment at the Lateglacial-Holocene transition in Vorpommern (Northeast Germany), in Terberger, T., Eriksen, B. V., (2004), (eds.), Hunters in a changing world: Environment and archaeology of the Pleistocene – Holocene transition (ca. 11000 – 9000 BC.) in Northern Central Europe, Workshop of the U.I.S.P.P. – Commission XXXII at Greifswald September 2002, pp. 27-52.

Kuhn, S. L., (1989), Hunter-gatherer foraging organization and strategies of artifact replacement and Discard, in, Amick, D. S., Mauldin, R. P., (Eds.), Experiments in lithic technology, *British Archaeological Reports*, Oxford, pp. 33-47.

Kuhn, S. L., Clark, A. E., (2015), Artefact densities and assemblage formation: Evidence from Tabun Cave, *Journal of Anthropological Archaeology*, Vol. 38, pp. 8-16.

LaBelle, J. M., (2012), Hunter-Gatherer Adaptations of the Central Plains and Rocky Mountains of Western North America, in Eren, M., (Eds.), Hunter-Gatherer Behaviour: Human Response during the Younger Dryas, Walnut Creek, California, pp. 139-164.

Lahr, M. M., Foley, R. A., (1998), Towards a theory of modern human origins: Geography, demography, and diversity in recent human evolution, *American Journal of Physical Anthropology*, Vol. 107:S27, pp. 137-176.

Lahr, M.M. and Foley, R.A., (2003), Demography, dispersal and human evolution in the last glacial period, in: Van Andel, T.H., Davies, W., (Eds.), Neanderthals and modern humans in the European landscape during the last glaciation: Archaeological results of the Stage 3 Project, McDonald Institute for Archaeological Research., pp. 241-256.

Lang, B., Brooks, S. J., Bedford, A., Jones, R. T., Birks, H. J. B., Marshall, J. D., (2010), Regional consistency in Lateglacial chironomid-inferred temperatures from five sites in north-west England, *Quaternary Science Reviews*, Vol. 29, pp. 1528-1538.

Lewis, J. S. C., Rackham, J., (2011), Three Ways Wharf, Uxbridge: A Lateglacial and Early Holocene hunter-gatherer site in the Colne Valley, Monograph 1, Museum of London Archaeology, Lavenham Press.

Limondin-Lozouet, N., Antoine, P., (2001), Palaeoenvironmental changes inferred from malacofaunas in the Lateglacial and early Holocene fluvial sequence at Conty, northern France, *Boreas*, Vol. 30, pp. 148-164.

Lurie, R., (1989), Lithic technology and mobility strategies: the Koster site Middle Archaic, in Torrence, R., (Eds.), Time, energy and stone tools, New Directions in Archaeology, Cambridge University Press, pp. 46-56.

Lyman, R. L., (2008), Quantitative Paleozoology, Cambridge Manuals in Archaeology, Cambridge Press.

MacArthur, R. H., Pianka, E. R., (1966), On optimal use of a patchy environment, *American Naturalist* Vol. 100, pp. 603-609.

Mariezkurrena, K., (1983), Contribución al conocimiento del desarrollo de la dentición y el esqueleto postcraneal de Cervus elaphus, *Munibe*, Vol. 35, pp. 149-202.

Marín-Arroyo, A. B., (2009), Economic adaptations during the Late Glacial in northern Spain. A simulation approach, in Campana, D. V., (Eds.), Before Farming: The Archaeology and Anthropology of Hunter-Gatherers, Western Academic & Specialist Press, pp. 1-18.

Marín Arroyo, A. B., (2013), Human response to Holocene warming on the Cantabrian Coast (northern Spain): An unexpected outcome, *Quaternary Science Reviews*, Vol. 81, pp. 1–11.

Marín-Arroyo, A. B., González-Morales, M. R., (2009), Comportamiento económico de los últimos cazadores-recolectores y primeras evidencias de domesticación en el occidente de Asturias, La Cueva de Mazaculos II, *Trabajos de Prehistoria*, Vol. 66:1, pp. 47-74.

McCall, G. S., (2007), Behavioral ecological models pf lithic technological change during the later Middle Stone Age of South Africa, *Journal of Archeological Science*, Vol. 34, pp. 1738-1751.

Meeks, S. C., Anderson, D. G., (2012), Evaluating the Effect of the Younger Dryas on Human Population Histories in the Southeastern United States, in Eren, M., (Eds.), Hunter-Gatherer Behaviour: Human Response during the Younger Dryas, Walnut Creek, California, pp. 111-138.

Mellars, P., (1998), The impact of climatic chnages on the demography of late Neandertal and early anatomically modern populations in Europe, in: Akazawa, T., Aoki, K., Bar-Yosef, O. (Eds.), Neandertals and Modern Humans in Western Asia, Plenum Press, New York, pp. 493-507.

Meltzer, D. J., Holiday, V. T., (2010), Would North American Paleoindians have noticed Younger Dryas age climate change? *Journal of World Prehistory*, Vol. 23, pp. 1-41.

Mithen, S., Wicks, K., Pirie, A., Riede, F., Lane, C., Banerjea, R., Cullen, V., Gittins, M., Pankhurst, N., (2015), A Lateglacial archaeological site in the far north-west of Europe at Rubha Port an t-Seilich, Isle of Islay, western Scotland: Ahrensburgian-style artefacts, absolute dating and geoarchaeology, *Journal of Quaternary Science*, Vol. 30:5, pp. 396-416.

Morgan, C., (2015), Is it Intensification Yet? Current Archaeological Perspectives on the Evolution of Hunter-Gatherer Economies, *Journal of Archaeological Research*, Vol. 23, pp. 163-213.

Morgan, C., Losey, A., Adams, R., (2012), High-altitude hunter-gatherer residential occupations in Wyoming's Wind River Range, *North American Archaeologist*, Vol. 33:1, pp. 35-79.

Morrow, J. E., (1997), End scraper morphology and use-life: An approach for studying Paleoindian lithic technology and mobility, *Lithic Technology*, Vol. 22: 1, pp. 70-85.

Mussi, M., Peresani, M., (2011), Human settlement of Italy during the Younger Dryas, *Quaternary International,* Vol. 242, pp. 360-370.

Myers. A., (1989), Reliable and maintainable technological strategies in the Mesolithic of mainland Britain, in Torrence, R., (Eds.), Time, energy and stone tools, New Directions in Archaeology, *Cambridge University Press*, pp. 78-91.

Nakazawa, Y., Iwase, A., Akai, F., Izuho, M., (2011), Human responses to the Younger Dryas in Japan, *Quaternary International*, Vol. 242, pp. 416-433.

Odell, G. H., (1981), The morphological express at function junction: Searching for meaning in lithic tool types, *Journal of Anthropological Research*, Vol. 37: 4, pp. 319-342.

Odell, G. H., (2000), Stone Tool Research at the End of the Millennium: Procurement and Technology, *Journal of Archaeological Research*, Vol. 8, No. 4.

Odell, G. H., (2001), Stone Tool Research at the End of the Millennium: Classification, Function, and Behaviour, *Journal of Archaeological Research*, Vol. 9, No. 1.

Odell, G. H., (2004), Lithic Analysis, Manuals in Archaeology Method, Theory, and Practice, Kluwer Academic/Plenum Publishers.

Osborn, A. J., (1999), From global models to regional patterns: possible determinants of Folsom hunting weapon design, diversity, and complexity, in: Amick, D.S., (Eds.), Folsom lithic technology: explorations in structure and variability, International Monographs in Prehistory, Ann Arbor, pp. 188-213.

Oswalt, W.H., (1973), Habitat and Technology: The Evolution of Hunting, *Holt,* Rinehart and Winston, New York.

Parry, W. J., Kelly, R. L., (1987), Expedient core technology and sedentism, in Johnson, J. K., Morrow, C. M., (Eds.), The organization of core technology, *Westview Press*, pp. 285-304.

Pettitt, P., White, M., (2012), The British Palaeolithic: Hominin societies at the edge of the Pleistocene world, London: Routledge.

Ponel, P., Coope, R., Antoine, P., Limondin-Lozouet, N., Leroyer, C., Munaut, A. V., Pastre, J. F., Guiter, F., (2005), Lateglacial palaeoenvironments and palaeoclimates from Conty and Houdancourt, northern France, reconstructed from beetle remains, *Quaternary Science Reviews*, Vol. 24, pp. 2449-2465.

Riel-Salvatore, J., Barton, M. C., (2004), Late Pleistocene Technology, Economic Behavior, and Land-Use Dynamics in Southern Italy, American Antiquity, Vol. 69:2, pp. 257-274.

Riel-Salvatore, J., Popescu, G., Barton, C. M., (2008), Standing at the gates of Europe: Human behavior and biogeography in the southern Carpathians during the Late Pleistocene, *Journal of Anthropological Archaeology*, Vol. 27:4, pp. 399-417.

Rillardon, M., Brugal, J. P., (2014), What about the Broad Spectrum Revolution? Subsistence strategy of hunter–gatherers in Southeast France between 20 and 8 ka BP, *Quaternary International*, Vol. 337, pp. 129-153.

Rindos, D., (1989), Diversity, variation and selection, in Leonard, R. D., Jones, G. T., (Eds.), Quantifying diversity in archaeology, Cambridge University Press, pp. 13-23.

Rolland, N., Dibble, H., (1990), A New Synthesis of Middle Paleolithic Variability, *American Antiquity*, Vol. 55, pp. 480-499.

Roth, B. J., Dibble, H. L., (1998), Production and transport of blanks and tools at the French Middle Paleolithic site of Combe-Capelle Bas, *American Antiquity*, Vol. 63, pp. 47-62.

Sato, H., Izuho, M., Morisaki, K., (2011), Human cultures and environmental changes in the Pleistocene-Holocene transition in the Japanese Archipelago, *Quaternary International*, Vol. 237, pp. 93-102.

Shennan, S.J., (2001), Demography and cultural innovation: A model and some implications for the emergence of modern human culture. *Cambridge Archaeological Journal*, Vol. 11, pp. 5-16.

Shott, M., (1986), Technological Organization and Settlement Mobility: An Ethnographic Examination, *Journal of Anthropological Research*, Vol. 42:1, 15-51.

Simpson, E. H., (1949), Measurement of Diversity, *Nature*, Vol. 163, pp. 688.

Smallwood, A. M., Jennings, T. A., Anderson, D. G., Ledbetter, J., (2015), Testing for evidence of Paleoindian responses to environmental changes during the Younger Dryas chronozone in Georgia, *Southeastern Archaeology*, Vol. 34:1, pp. 23-45.

Smith, G. M., (2011), Shifting stones and changing homes: using toolstone ratios to consider relative occupation span in the northwestern Great Basin, *Journal of Archaeological Science*, Vol. 38, pp. 461-469.

Sobrinoa, C. M., Heirib, O., Hazekampc, M., van der Veldenc, D., Kirilovac, E. P., García-Moreirasa, I., Lotterc. A. F., (2013), New data on the Lateglacial period of SW Europe: a high resolution multiproxy record from Laguna de la Roya (NW Iberia), *Quaternary Science Reviews*, Vol. 80, pp. 58-77.

Sommer, R. S., Benecke, N., Lõugas, L., Nelle, O., Schmölcke, U., (2011), Holocene survival of the wild horse in Europe: a matter of open landscape? *Journal of Quaternary Science*, Vol 26:8, pp. 805-812.

Steffensen, J. P., Andersen, K. K., Bigler, M., Clausen, H. B., Dahl-Jensen, D., Fischer, H., Goto-Azuma, K., Hansson, M., Johnsen, S. J., Jouzel, J., Masson-Delmotte, V., (2008), High-resolution Greenland ice core data show abrupt climate change happens in few years. *Science*, Vol. 321:5889, pp. 680-684.

Stevens, R. E., Hermoso-Buxán, X. L., Marín-Arroyo, A. B., Morales, M. R. G., Straus, L. G., (2014), Investigation of Late Pleistocene and Early Holocene palaeoenvironmental change at El Mirón cave (Cantabria, Spain) - Insights from carbon and nitrogen isotope analysis of red deer, *Palaeogeography, Palaeoclimatology, Palaeoecology*, Vol. 414, pp. 46-60.

Stevens, R. E., Jacobi, R., Street, S., Germonpre, M., Conard, N. J., Münzel, S. C., Hedges, R. E. M., (2008), Nitrogen isotope analyses of reindeer (Rangifer tarandus), 45,000 BP to 9,000 BP: Palaeoenvironmental reconstructions, *Palaeogeography, Palaeoclimatology, Palaeoecology*, Vol. 262, pp. 32-45.

Stiner, M., Munro, N. D., Surovell, T. A., (2000), The tortoise and the hare: Small-game use, the broad-spectrum Revolution, and Paleolithic demography, *Current Anthropology*, Vol. 41:1, pp. 39-79.

Straus, L. G., (1991), Epipaleolithic and Mesolithic Adaptations in Cantabrian Spain and Pyrenean France, *Journal of World Prehistory*, Vol. 5:1, pp. 83-104.

Straus, L. G., (1991), Southwestern Europe at the Last Glacial Maximum, *Current Anthropology*, Vol. 32:2, pp. 189-199.

Straus, L. G., (1996), The Archaeology of the Pleistocene-Holocene Transition in southwest Europe, in: Straus, L. G., Eriksen, B. V., Erlandson, J. M., Yesner, D. R., (Eds.), Humans at the end of the Ice Age: The archaeology of the Pleistocene-Holocene Transition, Interdisciplinary Contributions to Archaeology, Plenum Press, New York and London, pp. 83-100.

Straus, L. G., (2011), Were there human responses to Younger Dryas in Cantabrian Spain? *Quaternary International*, Vol. 242, pp. 328-335

Straus, L. G., (2013), After the Deep Freeze: Confronting "Magdalenian" realities in Cantabrian Spain and beyond, *Journal of Archaeological Method and Theory*, Vol. 20, pp. 236-255.

Street, M., (1991), Bedburg-Konigshoven: A Pre-Boreal Mesolithic site in the Lower Rhineland, Germany, in Barton, N., Roberts, A. J., Roe, D. A, (Eds.), The Late Glacial in north-west Europe: Human adaptation and environmental change at the end of the Pleistocene, CBA Research Report, No. 77, Council for British Archaeology, pp. 256-270.

Tallavaara, M., Luoto, M., Korhonen, N., Järvinen, H., Seppä, H., (2015), Human population dynamics in Europe over the Last Glacial Maximum, *Proceedings of the National Academy of Sciences*, 112:27, pp. 8232-8237.

Tarroso, P., (2008). Late Quaternary landscape dynamics in the Iberian Peninsula and Balearic Islands, University of Oporto.

Terberger, T., (2004), The Younger Dryas-Preboreal transition in northern Germany: Facts and concepts in discussion, in: Terberger, T., Eriksen, B. V., (2004), (Eds.), Hunters in a changing world: Environment and archaeology of the Pleistocene-Holocene transition (ca. 11,000-9,000 BC.) in Northern Central Europe, Workshop of the U.I.S.P.P., Commission XXXII at Greifswald September 2002, pp. 203-222.

Terberger, T., (2006a), From the first humans to the Mesolithic in the Northern German Lowlands - Current results and Trends, in Hansen, M. M., Pedersen, K. B., (2006), (Eds.), Across the western Baltic: Proceedings from an archaeological conference in Vordingborg, Udgivet af Sydsjallands Museum 2006, pp. 23-56.

Terberger, T., (2006b), The Mesolithic hunter-fisher-gathers on the Northern German Plain, in Hansen, M. M., Pedersen, K. B., (2006), (eds.), Across the western Baltic: Proceedings from an archaeological conference in Vordingborg, Udgivet af Sydsjallands Museum 2006, pp. 111-185.

Terberger, T., Barton, N., Street, M., (2009), The Late Glacial reconsidered – Recent progress and interpretations, in Street, M., Barton, N., Terberger, T., (2009), (Eds.), Humans, environment and chronology of the Late Glacial of the North European Plain, Proceeding of Workshop 14 (Commission XXXII) of the 15th U.I.S.P.P. Congress, Lisbon, September 2006, pp. 189-207.

Thomas, D. H., (1989), Diversity in hunter-gatherer cultural geography, in Leonard, R. D., Jones, G. T., (Eds.), Quantifying diversity in archaeology, Cambridge University Press, pp. 85-91.

Torrence, R., (1983), Time Budgeting and Hunter-Gatherer Technology, in Bailey, G., (Eds.), Hunter-Gatherer Economy in Prehistory: A European Perspective, Cambridge University Press, pp. 11 -22.

Torrence, R., (1989), Re-tooling: Towards a behavioural theory of stone tools, in Torrence, R., (Eds.), Time, energy and stone tools, Cambridge University Press, pp. 57-66.

Usinger, H., (2004), Vegetation and climate of the lowlands of northern Central Europe and adjacent areas around the Younger Dryas - Preboreal transition - with special emphasis on the Preboreal oscillation, in Terberger, T., Eriksen, B. V., (2004), (Eds.), Hunters in a changing world: Environment and archaeology of the Pleistocene - Holocene transition (ca. 11000 - 9000 BC.) in Northern Central Europe, Workshop of the U.I.S.P.P. - Commission XXXII at Greifswald September 2002, pp. 1-26.

Uzquiano, P., (1992), The Late Glacial/Postglacial transition in the Cantabrian Cordillera (Asturias and Cantabria, Spain) based on charcoal analysis, *Palaios*, Vol. 7, pp. 540-547.

Van Andel, T.H., Davies, W., Weninger, B., (2003), The human presence in Europe during the Last Glacial period I: Human migrations and the changing climate, in: Van Andel, T.H., Davies, W., (Eds.), Neanderthals and Modern Humans in the European Landscape during the Last Glaciation, McDonald Institute Monographs, McDonald Institute for Archaeological Research, pp. 31-56.

Van der Plicht, J., Van Geel, B., Bohncke, J. P., Bos, J. A. A., Blaauw, M., Speranza, A. O. M., Muscheler, R., Bjork, S., (2004), The Preboreal climate reversal and a subsequent solar-forced climate shift, *Journal of Quaternary Science*, Vol. 19:3, pp. 263-269.

Van Geel, B, Kolstrup, E., (1978), Tentative explanation of the Lateglacial and Early Holocene climatic changes in north-western Europe, *Geologie en Mijnbouw*, Vol. 57, pp. 87–89.

Van Geel, B, Bohncke, S. J. P., Dee, H., (1981), A palaeoecological study of an Upper Late Glacial and Holocene sequence from 'de Borchert', the Netherlands, *Review of Palaeobotany and Palynology*, Vol. 31, pp. 367-448.

Van Geel, B., Coope, G. R., Van der Hammen, T., (1989), Palaeoecology and stratigraphy of the Lateglacial type section at Usselo (The Netherlands), *Review of Palaeobotany and Palynology*, Vol. 60, pp. 25-129.

Vasil'ev, S. A., (2011), Old traditions, new tendencies: Final Paleolithic cultural development in southern Siberia, *Quaternary International* 242, pp. 371-378.

Vegas-Vilarrúbia, T., González-Sampériz, P., Morellón, M., Gil-Romera, G., Pérez-Sanz, A., Valero-Garcés, B., (2013), Diatom and vegetation responses to Late Glacial and Early Holocene climate changes at Lake Estanya (Southern Pyrenees, NE Spain), *Palaeogeography, Palaeoclimatology, Palaeoecology*, Vol. 392, pp. 335-349.

Verpooten, J., Nelissen, M., (2010), Sensory exploitation and cultural transmission: the late emergence of iconic representations in human evolution, *Theory in Biosciences*, Vol. 129:2-3, pp. 211-221.

Vierra, R. K., (1983), Typology, classification and theory building, in Whallon, R., Brown, J. A., (Eds.), Essays in archaeological typology, *Centre for American Archaeology*, pp. 162-175.

Walker, M. J. C., Coope, G. R., Lowe, J. J. (1993). The Devensian (Weichselian) Lateglacial palaeoenvironmental record from Gransmoor, East Yorkshire, England, *Quaternary Science Reviews*, Vol. 12, pp. 659-680.

Walker, M. J. C., Bohncke, S., Coope, G. R., O'Connel, M., Usinger, H. and Verbruggen, C., (1994), The Devensian/Weichselian Late-Glacial in northwest Europe (Ireland, Britain, north

Belgium, The Netherlands, northwest Germany), *Journal of Quaternary Science*, Vol. 9, pp. 109-18.

Walker, M. J. C., Coope, G. R., Sheldrick, C., Turney, C. S. M., Lowe, J. J., Blockley, S. P. E. Harkness D. D., (2003), Devensian Lateglacial environmental changes in Britain: a multi-proxy environmental record from Llanilid, South Wales, UK, *Quaternary Science Reviews*, Vol. 22, pp. 475-520.

Walsh, K., (2005), Risk and marginality at high sltitudes: New interpretations from fieldwork on the Faravel Plateau, Hautes-Alpes, *Antiquity*, Vol. 79:304, pp. 289-305.

Walsh, K., Richer, S., Beaulieau, J. L. D., (2006), Attitudes to Altitude: Changing Meanings and Perceptions within a 'Marginal' Alpine Landscape-The Integration of Paleoecological and Archaeological Data in a High-Altitude Landscape in the French Alps, *World Archaeology*, Vol. 38:3, pp. 436-454.

Winterhalder, B., (1981), Optimal foraging strategies and hunter-gatherer research in anthropology: Theory and Models, in Winterhalder, B., Smith, E. A., (Eds.), Hunter-gatherer foraging strategies: Ethnographic and archaeological analyses, University of Chicago Press, pp. 13-35.

Wymer, J. J., (1962), Excavations at the Maglemosian sites at Thatcham, Berkshire, *Proceedings of the Prehistoric Society*, Vol. 28, pp. 329-361.

Young, L. C., (1994), Lithics and adaptive diversity: An examination of limited-activity sites in Northeast Arizona, *Journal of Anthropological Research*, Vol. 50:2, pp. 141-154.

Zagwijn, W. H., (1994), Reconstruction of climate change during the Holocene in western and central Europe based on pollen records of indicator species, *Vegetation History and Archaeobotany*, Vol. 3, pp. 65-88.

Zeder, M. A., (2011), The Origins of Agriculture: New data, new ideas, *Current Anthropology*, Vol. 52:S4, pp. S221-S235.

Zvelebil, M., (1984), Clues to recent evolution from specialised technologies? *Nature*, Vol. 307, pp. 314-315.

Appendix 1

Additional Materials

Logarithmic Scale

Ln Scale
1 = 3
2 = 10
3 = 20
4 = 50
5 = 150
6 = 400
7 = 1000
8 = 3000
9 = 10000
10 = 20000
11 = 60000
12 = 150000

Glossary of Tool Type Definitions

Assemblage – Group of artefacts from the same archaeological context.

Blanks – Flakes and blades that are potentially modifiable into a specific form but have not yet been modified/retouched (Andrefsky, 2005).

Blades – Rectangular flakes and elongated triangular flakes whose length is greater than or equal to twice their width (Shea, 2016).

Bladelets – Prismatic blades less than 50mm long and narrower than 12mm wide (Shea, 2016).

Borers – Flake tools or bifacial tools used in a rotary motion and used to perforate materials (Andrefsky, 2005).

Burins – Flake tools with a chisel edge that was produced by the removal of two flakes or 'spalls' at right angles to one another to create a sharp and durable edge (Andrefsky, 2005). Microwear analysis suggests that some burins were used for carving hard materials, but may have been also used to re-sharpen a use-damaged edge, to shape tools so that they fit better in the hand or in a handle, or for use as a core (Shea, 2013).

Burin Spalls – Flakes detached by burination that propagates perpendicular to the ventral surface of the flake from which it was detached. Potentially used as a tool (Shea, 2016).

Chips/Debris – Are unmodified lithic artefacts shorter than 2-3cm (Shea, 2016).

Cores – Used for propagating flakes and blades for tool production. They are rocks that feature relatively large (>20mm long) fracture scars on their surfaces from flake and blade removals. They can also be used as tools (Shea, 2016).

Debitage – See 'Waste'.

Denticulates – Serrated or toothed edged flake tools (Andrefsky, 2005).

Domestic Tools – Classified here as tools that are thought to be used predominantly for home/base camp activities such as wood/bone/antler-working, meat/plant processing, hide scraping, and tool manufacturing. Here these tool types include endscrapers, burins, borers, notches, denticulates, truncations, splintered pieces, retouched pieces, and Long Blades. As with the hunting tool classification, it is recognised that these typologies are subjective and such tools may have been used for a variety of tasks including hunting, but making such an assumption was necessary in order to distinguish between site types using only stone tools.

Endscrapers – Flake tools with retouch on the distal end. The retouched area has an edge angle that approaches 60˚ to 90˚ (Andrefsky, 2005).

Flakes – Relatively flat and sharp-edged objects detached from cores by fracture (Shea, 2016).

Hammerstones/Percussors – Rocks used to initiate fractures in cores and retouched tools. Mostly rounded pebbles or cobbles, but also angular rocks, cores, flakes, and retouched artefacts have been used (Shea, 2016), and also bone and antler pieces (Andrefsky, 2005).

Hunting Tools – Classified here as tools that are thought to be predominately used as hunting tools in various forms of projectiles. Here these tool types include points and microliths. It is recognised that these typologies are subjective (especially microliths) and such tools may have also been used for other tasks, but the decision was made to classify these tools as hunting tools to form a mechanism in which to distinguish between site types using only stone tools which would otherwise be impossible.

Long Blades – Also known as ‘bruised blades’ are large, robust, flakes and blades that are sometimes crested, which display signs of very heavy edge damage through stepped, invasive scalar scarring, usually confined to the ventral surface. Believed to be used for heavy-duty chopping of animal bone and antler (Barton, 1986; Lewis and Rackham, 2011)

Microburins – Debris of geometrical microlithic industries, usually discarded proximal and distal ends of a blade (Andrefsky, 2005).

Microliths – Flakes or flake fragments <5cm long that have been steeply retouched (“Backed” or “Truncated”) along at least one of their edges with at least some portion of an edge remains unretouched. There are complex typologies for this tool type based on characteristics such as their plan shape (triangles, points, rectangles, trapezoids, crescents) and the steepness and invasiveness of the retouch on the backed/truncated edges, amongst others. Considered functionally versatile and have been found in archaeological contexts attached to arrows, sickles, knives, plant processing tools, and woodworking tools (Shea, 2013). But there has been a historic overall prevailing attitude formed from the context in which a large proportion of microliths have been found, that microliths were used primarily as components in hunting weaponry (Torrence, 2002). As such, and due to the lack of simple tool typologies to attribute to hunting weaponry, microliths are simply assumed for the purposes of this study to be predominantly used as components in hunting tools (i.e. there is a higher chance that a microlith represents part of a hunting tool rather than a domestic tool and is more likely to represent the presence of hunting activities).

Notches – Flakes, blades, fragments, or cores in which an indentation has been retouched on a side or end. The function is unclear, and possibly used for multiple functions, but have historically been described as implements for smoothing or notching rounded, elongated objects such as arrow shafts (Gibbon, 1998).

Points – Flake/blade fragments on which two retouched edges converge to form a sharp triangular projection (Shea, 2016) and contains a hafting area. Usually identified as arrow points, dart points, and spear points (Andrefsky, 2005) and thus considered hunting tools in this study.

Retouched Artefacts/Pieces – Flakes and blades and their fragments that have a series of smaller fractures detached from their edge (retouch). Continuous damage running for a centimetre along an edge extending more the 2-3mm onto either side of an edge is almost universally considered to be retouch (Shea, 2016).

Riesenklingen – Similar to Long Blade. A large blade/flake artefact recognised in earlier German literature.

Splintered Pieces – Also known as bipolar cores or scaled pieces. Defined as cores resulting from bipolar core reduction (fracture initiated by striking the uppermost surface of a core or flake that is resting on a hard surface) (Shea, 2016). Considered functionally versatile, but have been historically defined as 'wedges' used in antler and bone working, although this has been contested (Shott, 1999).

Truncations – Classified as flake fragments with steep retouch on either the lateral edges or its distal/proximal ends (Shea, 2016).

Waste – Defined here as detached pieces (flakes, flake fragments and other by-products) discarded during the reduction process (Shea, 2016; Andrefsky, 2005).

References

Barton, R. N. E., (1986), Experiments with long blades from Sproughton, near Ipswich, Suffolk, in Roe, D. A., (eds.), Studies in the Upper Palaeolithic of Britain and north-west Europe, BAR International Series 296, Oxford, pp. 129-141.

Gibbon, G., (1998), Archaeology of Prehistoric Native America: An Encyclopedia, New York: Garland Publishing.

Lewis, J. S. C., Rackham, J., (2011), Three Ways Wharf, Uxbridge: A Lateglacial and Early Holocene hunter-gatherer site in the Colne valley, Museum of London Archaeology, Monograph 51.

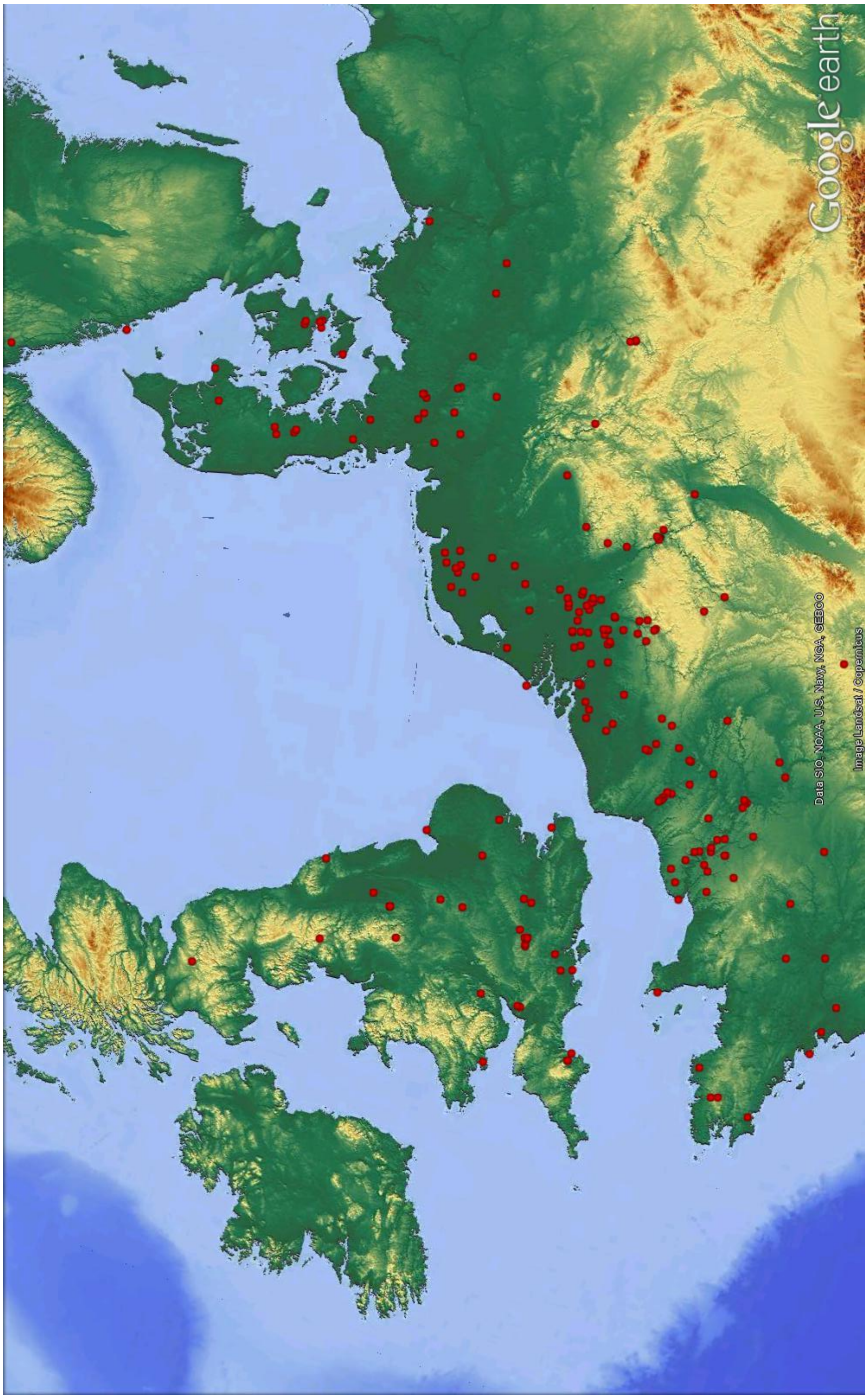
Shea, J. J., (2013), Lithic Modes A—I: A New Framework for Describing Global-Scale Variation in Stone Tool Technology Illustrated with Evidence from the East Mediterranean Levant, *Journal of Archaeological Method and Theory*, Vol. 20:1, pp. 151-186.

Shea J.J., (2016), Stone Tools in Human Evolution: Behavioural Differences among Technological Primates, Cambridge University Press.

Shott, M. J., (1999), On Bipolar Reduction and Splintered Pieces, *North American Archaeologist*, Vol. 20:3, pp. 217-238.

Torrence, R., (2002), Thinking Big about Small Tools, Archaeological Papers of the American Anthropological Association, Vol. 12:1, pp. 179-189.

Map Showing the Location of Sites with Lithic Data Included in this Study (Google Earth with overlay from US Navy Satalite Data 2017)



Appendix 2

Assemblage Data

Key

B = Blades

B'lets = Bladelets

F = Flakes

Bl = Blanks

C = Cores

T = Tools

ES = Endscraper

Bu = Burin

Bo = Borer

SP = Splintered Pieces

No = Notches

Dent = Denticulates

Trunc = Truncation

P = Points

ML = Microliths

MBu = Micro-Burins

MF = Multi-Function

LB = Long Blade

RF = Retouched and Utilised Flakes

RB = Retouched and Utilised Blades

RB'lets = Retouched and Utilised Bladelets

TR = Total Retouched and Utilised Pieces

TL = Total Lithic Artefacts

RK = Riesenklingen

RMS = Raw Material Source

RMQ = Raw Material Quality

Northwest European Allerod Assemblage Data

Country	Site Name	Assemblage	Climate	Culture	B	B'lets	B+B'lets	F	Bl	C	T	ES	Bu	Bo	SP	No	Den	Trun	P	ML	Mbu	MF	Knives	RK	LB	Other	RF	RB	RB'lets	TR	TL	Waste	NTAXA	Site Type	Ex Year	Area (m2)	Altitude	RMS	RMQ	Source
France	Foumares		Allerod	Fed	87		87	109	196	20	11	6	2						2							1					308	81	4				81			Fosse (1994)
France	Le Closeau	Locus 4	Allerod	Unknown					2300		351															351					2651			Open Air	1994	182	27			Teyssandier (2000)
France	Le Quenneville		Allerod	Fed	181		181	289	470	37	32	15	4						2							7		4		4	539		5				92			Fosse (1994)
France	Mirville		Allerod	Fed					270		49	11	10			4	4	4	4							6		6		6	319		8				105			Fosse (1994)
France	Pincevent	Magdalenian Habitation 1	Allerod	L. Mag	61	71	132		132	36	206	25	120	11		11		25				10				0		4		4	374		7	Open Air	1964		47			Leroi-Gourhan + Brezillon (1966)
France	Saint-Pierre-du-Bosguerard		Allerod	L. Mag	71		71	149	220	21	38	8	5	2		3		4	11							1		4		4	418	142	8	Open Air	1954		160	Local	Medium	Bosselin (1982)
France	Ambenay		Allerod	Fed	246		246	299	545	43	41	5	9					6								21					629		4	Open Air	1982-1986		206	Local	Poor	Valentin et al. (2004)
France	Ambenay	Locus 33	Allerod	Fed	163	14	177	447	624	22	99	9	6					4	16							34		30		30	1095	350	6	Open Air	1982-1986	130	206	Local	Poor	Valentin et al. (2004)
France	Ambenay	Surface Survey	Allerod	Fed	15		15		15		278	54	38					9	39							116		22		22	256		6	Open Air	1982-1986		206	Local	Poor	Valentin et al. (2004)
France	Bas-Fayaux		Allerod	Fed				85	85	5																					162	72					142			Cliquet + Lautridou (1994)
France	Verberie		Allerod	L. Mag		68	68		68		248	17	76	15	1	13	1	26				10				89					316		9	Open Air			31			Audouze et al. (1981)
Germany	Borneck	Borneck-Ost	Allerod	Fed	383		383	892	1275	12	59	27	2					2	1							27					1351	5	5	Open Air	1946-1949	73	44	Local	Medium	Kotthaus (2013)
Germany	Goch	Level RME1	Allerod	Unknown				79	79	1	24															0					122	18					18			Heinen et al. (1996)
Germany	Henauhof	Henauhof West	Allerod	Unknown	68		68	57	125	2	34	2	6	2		1		2	3	1						12		5		5	161		9	Open Air	1987	83	584	Local	Poor	Jochim (1995)
Germany	Jena		Allerod	L. Mag	19		19	60	79	1	37		1	3	2							1				15		15		15	117		6				147			Hemmann et al. (2008)
Germany	Olknitz		Allerod	L. Mag	2199		2199	4746	6945	81	2507	81	251	139	134			47				9				923		923		923	19165	10020	8	Open Air		850	25			Hemmann et al. (2008)
Germany	Rothenstien		Allerod	L. Mag	102		102	132	234	2	48	1	4	1	1			2								20		19		19	284		7				165			Hemmann et al. (2008)
Germany	Russelsheim	Russelsheim 122	Allerod	Unknown	336	415	751	771	1522	72	308	134	21	1				31		4		4				71		42		42	2120	218	8				91			Loew (2005)
Germany	Salzkotten-Thüle		Allerod	Fed				1602	1602	21	157	60	4		1	1		6	14			1				38		32		32	3082	1302	9	Open Air	2001	230	98	Local		Heidenreich (2009)
Germany	Weitsche		Allerod	Fed			1360	1305	2665	84	560	198	192	4	1	4		28	67			7						37		59	3352	43	9				17			Veil + Breest (1994)
Netherlands	Haule	Haule V	Allerod	Fed	45		45	166	211		109	54	7	18		7		0	1							14	5	3		8	345	25	7	Open Air	1955		6.28			Houtsma et al. (1996)
Belgium	Rekem		Allerod	Fed	1211		1211	4419	5630	215	1312	170	274	41				76				20				396		10	48	335	23496	16339	7	Open Air	1985	17000	41	Local	Variable	De Bie + Casper (2000)
Germany	Teltwisch	Teltwisch 5	Allerod	Fed	102		102	535	637	16	64	21	20	2					2	1						18					717		6	Open Air	1970		48			Tromnau (1973)
Germany	Teltwisch	Teltwisch-Sud	Allerod	Fed	17		17	400	417	13	65	8	4						3							50					495		4	Open Air	1968		48			Tromnau (1973)
Denmark	Egtved		Allerod	Fed	45		45	59	104	4	50																5	45		50	158		1	Open Air	1983	174	74	Local	Good	Fischer (1990)
Denmark	Slotseng	Federmesser Assemblage	Allerod	Fed	10368		10368		10368	110	296	112	22	4		4			130			3								21	10780	6	7	Open Air	1989	48	38			Holm (1991)
France	Blaru		Allerod	Fed	151		151	377	528	64	59	17	7	1			1	3	23							6				1	660	9	8	Open Air	1975	90	91	Local		Fosse (1993)
France	D'Etouvie		Allerod	Azilian	322	137	459	436	895	33	110	15	45	1	2	2		3	13							15	5	9		14	1571	577	9	Open Air	1952	300	18		Good	Fagnart (1982)
Netherlands	Horn-Haelen		Allerod	Fed	162		162	622	784	66	330	111	57	8					72			3				44	21	14		35	1180		7	Open Air	1955	60000	21	Local	Variable	Stoop (2014)
UK	Rookery Farm		Allerod	Fed	243		243	111	354	2	28							4	3	1						9	1	3		11	656	263	5	Open Air	2002	42	15	Local	Variable	Conneller et al. (2009)
Belgium	Verrebroek	"Dok 2"	Allerod	Uknown						2	6	1	1													1				3	542	534	4	Open Air	1999	24	6	Non Local	High	Crombe et al. (1999)
UK	La Sagesse Convent		Allerod	Fed	213		213	552	765	91	131	12	4			1		4		5							100	5		105	2342	1355	6	Open Air	1999		14	Local	High	Conneller et al. (2007)
UK	Kent's Cavern		Allerod	Fed					102	3	50	8	8						15							19					155		4	Cave	1880	6	84			Bonsall (1977)
UK	Torbryan Six Cave		Allerod	Fed					14		7	3	1						1							2					21		4	Cave	1890	4	77			Bonsall (1977)
UK	Three Holes Cave		Allerod	Fed					23		20								6											14	43		2	Cave	1961	4	81			Bonsall (1977)
UK	Aveline's Hole		Allerod	Fed					222		31		1						26							4					253		3	Cave	1925	6	143			Bonsall (1977)
UK	King Arthur's Cave		Allerod	Unkown					74	1	29	3	3						13							10					104		4	Cave	1927	6	113			Bonsall (1977)
UK	Victoria Cave		Allerod	Fed					12		7	1							4							2					19		3	Cave	1932	6	456			Bonsall (1977)
UK	Pin Hole Cave		OD/A	Fed					35		17	2							13		1					1					52		3	Cave	1928	4	91			Bonsall (1977)
UK	Church Hole Cave		OD/A	Fed					29		6		1						3							2					35		3	Cave	1876	4	92			Bonsall (1977)
UK	Mother Grundy's Parlour		Allerod	Fed					236	5	119	19	8						47		2					43					360		4	Cave	1925	4	86			Bonsall (1977)
UK	Howburn Farm		OD/A	Havelte	230	26	256	513	769	43	180	59		2		2	1	8	23	6		2				6				71	1099	86	10	Open Air	2005	79	265	Not-Local	High	Saville et al. (2007)
UK	Nea Farm		Allerod	Fed	340	78	431	597	1028	31	61	16	3	5				5	2								16	5	21	30	1609	520	6	Open Air	2000	20	48	Not-Local	High	Barton et al. (2009)
France	Evreux	III	Allerod	Azilian						47	70	10	7	1		13	11	4	16							8							8	Open Air	1950		123			Bordes + Fitte (1951)
France	La Grotte de Gouy		Allerod	Azilian	60	3	63	33	96	1	16	2				1		2	3									8		8		113	5	Cave			74		Variable	Bordes et al. (1974)
France	Bois d'Holnon à Attilly		Allerod	Fed	1902	1193	3095	4934	8029	167	511	378	57	8		12	3	15	16			3				11		8		8	10196	1489	10	Open Air	1974	200	130	Local	Good	Fagnart (1988)
France	Dreuil-lès-Amiens		Allerod	Fed	530		530	601	1131	35	120	24	34	8		1		7	25	1		4				2	5		9	14	1661	376	10	Open Air	1980	163	18	Local	Very Good	Fagnart (1988)
Germany	Kettig		Allerod	Fed						61	369	118	59	5					102											85	24098		5	Open Air	1993	242	110	Not-Local	High	Baales (2002)
France	Hamel		Allerod	Fed					137		92	20	30	7		12	3	8	9			3						2	2		229		8	Open Air	1974		65			Fagnart (1988)
France	Prés du Mesnil		Allerod	Fed	40	2	42	52	94	4	8	1	1					1	5												148	46	4	Open Air	1992		14	Local	Good	Coudret et al. (1995)
France	Plats Monts		Allerod	Fed						7	272	73	121	7		12	3	19	14	2		3				7		8		11			11	Open Air	1967		67			Fagnart (1988)
France	Quillien	210	Allerod	Azilian	23	263	286	370	656	249	296	23		2	2			6		10	1					6	170	3	73	246	2368	1167	7	Open Air	1984	50000	210	Non-Local	High	Gouletquer + Leopold (1991)
France	Belloy-sur-Somme	White Series	Allerod	Fed	210	56	210	425	691	51	72	8	4	3	1	1		8	35							3	6	3		9	814		9	Open Air	1984	916	18	Local	Good	Fagnart (1992)
Belgium	Harelbeke		Allerod	Fed					1469	87	337	103	116	2	3	13		9	28	9		6					29	19		48	2183	372	10	Open Air	1975	20000	-3	Non-Local	Good	Vermeersch (1976)
Netherlands	Koelbroek	Site 1	Allerod	Fed					337		40		26																	14	1004	617	2	Open Air	1987	24	28	Local		Deeben (2012)
Netherlands	Norgervaart		Allerod	Fed	150		150	15	165	21	83	17	9	6					30							8		13		13	391	155	6	Open Air	1968	5	12	Local	Good	Paddayya (1973)
Netherlands	Schipsloot at Een		Allerod	Fed	1279		1279	4665	5944	411	872	406	161	37		35		6	101	3	1	18								104	8785	1558	9	Open Air	1971	400	5.5	Local	Poor	Houtsma et al. (1981)
Netherlands	Eexterveen		Allerod	Fed	103		103	118	221	52	229	148	20	4		7		5	27							1				17	553	51	8	Open Air	1997		2			Beuker et al. (2003)
Netherlands	Heythuysen-de Fransman	HF-Ia	Allerod	Fed			1003	2162	3165	153	989	303	296	30					129			24				15	121	71		192	4339	32	7	Open Air	1961	1600	30	Local	Good	Stoop (2014)
Netherlands	Nederweert-De Banen		Allerod	Fed							1333	632	456						224			21											4	Open Air	1955		31			Stoop (2014)
Netherlands	Merselo-Zwarte Water		Allerod	Fed		83	83		83		42	18	18						6												125		3	Open Air			30			Stoop (2014)
Netherlands	Loobeek-Esakker		Allerod	Fed	27		27	58	85	7	4			1					2			1									98	2	3	Open Air	1990	1400	18			Stoop (2014)
Netherlands	Blerick-Koelbroek		Allerod	Fed				119	119		15	5	3						3											4	134		4	Open Air	1989		28			Stoop (2014)
Netherlands	Baexem -Beekkant		Allerod	Fed		20	20	87	107	4	10	2	1					1	4								1	1		2	195	74	5	Open Air	2007		30			Stoop (2014)
Germany	Koblenz		Allerod	Fed			152	799	951	8	110	69	2						13											26	1641	572	4	Open Air	1966	16.7	120	Not-Local		Baales et al (1998)
France	Chaloignes	Locus 2	Allerod	Azilian	34	33	67	208	275	18	28	2				8	7	4	7												367		5	Open Air	1999	51	63	Local		Marchand et al. (2008)
France	Chaloignes	Locus 4	Allerod	Azilian	33	25	58	88	146	1	40		2						5												282	93		Open Air	1999	11	63	Local		Marchand et al. (2008)
France	Chaloignes	Locus 13	Allerod	Azilian			141	75	216	10	10					2		4	4								4				248	12	3	Open Air	1999	25	63	Local		Marchand et al. (2008)
France	Kerbizien		Allerod	Azilian	8	40	48	78	216		48		1		2				21								10	7	6	24	314	137	4	Rock Shelter	2011	11	190	Not-Local	High	Marchand et al. (2008)
Germany	Ahrenshöft	LA 58 D	Allerod	Havelte	335		335	186	521	11	78	12	11	12		4		2	3			5				1		29		29	774	164	9	Open Air	1995	22	5	Local		Weber et al. (2010)
Netherlands	Geldrop	3-4	Allerod	Fed	48		48	322	370		38	14	4	1					2			2								15	495	87	6	Open Air	1960's		20			Drenth (2015)
Netherlands	Oostelbeers		Allerod	Fed	547		547	2049	2596	40	460	102	134	8					39				7	7				28		163	3440	344	8	Open Air	1976	638	21			Arts + Deeben (1978)
Germany	Berlin-Tegel	Konzentrationen IX	Allerod	Fed						36	152	64	28	2	3				19								34	2		36	1730		6	Open Air	1961	4000	41		Poor	Wenzel (2009)
Belgium	Plinius-terrein		Allerod	Fed	269		269	120	389	25	398	74	21	8					21							116		158		158	812		6	Open Air	2006	158	76	Local	High	Dijkstra et al. (2006)
Germany	Niederbieber	Fläche II	Allerod	Fed	291	267	558	745	1303	18	64	14	12	3					35												4308	2923	4	Open Air	1981	126	93	Local		Gelhausen (2009)
Netherlands	Milheeze		Allerod	Fed	900		900	6739	7639	150	885	212	270	12					148	11		11					73	126		207	9466	792	7	Open Air	1958	250000	27	Non-Local	Good	Arts (2012)
France	Saint-Paer		Allerod	Azilian	2317	96	2413	7157	9570	510	502	243	48	1		16		16	116				24			25	2	11		13	10644	62	9	Open Air			20	Local	High	Watte (2013)
France	Éragny-sur-Epte		Allerod	Azilian	12	3	15	40	55	17	2						1											1		1	76	2	2	Open Air	1894		109	Local	Good	Watte (2010)
France	Héricourt-en-Caux	Late Palaeolithic Series	Allerod	Azilian	117	46	163	235	398	8	28	3	3			1			18						1			2		3	720	286	6	Open Air	2001	163	70	Local	Good	Watte (2008)
France	Ecourt-Saint-Quentin		Allerod	Tjongerien							283	81	130	7		12	3	19	15			1				7		8		8			10	Open Air	1961		67			Demolon + Tuffreau (1972)
Germany	Handeloh	FStNr 15	Allerod	Fed	522	428	950	1313	2263	317	610	330	123	5					41			3					41	67		108	3448	258	6	Open Air	1980		60			Breest + Graff (2007)
Germany	Hacklingen	FStNr19	Allerod	Fed	425		425	1299	1724	158	263	97	40	3					10							3	86	13		110	2414	251	6	Open Air	1996		30			Richter (2002)
Netherlands	Meer	IV	Allerod	Tjongerien			2594	4568	7162	117	970	189	198	56		30	16	30	259	2		23				36	0	59		131	13659	3589	11	Open Air	1994?		-2			Otte (1994)

Northwest European YD Assemblage Data

Country	Site Name	Assemblage Name	Climate	Culture	B	B'lets	B+B'lets	F	Bl	C	T	ES	Bu	Bo	SP	Axes	No	Den	Trun	P	ML	MBu	MF	LB	Saws	Other	RF	RB	RB'lets	TR	TL	Waste	NTAXA	Site Type	Ex Year	Area (m2)	Altitude	RMS	RMQ	Source
UK	Ossom's Cave		YD	Unknown					44	1	8	3	2							1						1		1		1	53		5	Cave	1954	2	210	N/A	N/A	Bonsall (1977)
Belgium	Zonhoven-Molenheide		YD	Ahrens	797	1553	2350	3598	5948	110	414	26	36	1	1		9	1	39	182	24					65	12	11	7	30	11648	5176	11	Open Air	1996	100	76	Local	Variable	Vermeersch (2013)
Netherlands	Eersel-Panberg		YD	Ahrens							74	20	7							17						30				0	74		4	Open Air			28	N/A	N/A	Vermeersch (2008)
France	Bois du Brûle		YD	Ahrens	1330		1330	2220	3550	7	556	324	43	5					1	91			1							91	4113		7	Open Air	1909	20000	84	N/A	N/A	Fagnart (1988)
UK	Avington	Avington IV	YD	LB	2590		2590	1700	4290	60	73	9	2								34			6		11				11	14560	10137	6	Open Air	1978	18	86.4	Local	Good	Froom (2005)
Netherlands	Nijlen		YD	Ahrens	21	9	30	20	50	6																				0	156	100		Open Air			8	N/A	N/A	Self classified
Germany	Teltwisch	Teltwisch 2	YD	Ahrens	1200		1200	3300	4500	54	391	224	55	4						19	23					55				11	4945		7	Open Air	1968		48	N/A	N/A	Tromnau (1973)
Germany	Teltwisch	Teltwisch 4	YD	Ahrens	109		109	200	309	11	73	39	12	3						3			2			12		2		2	393		7	Open Air	1969		48	N/A	N/A	Tromnau (1973)
Germany	Teltwisch	Teltwisch 6	YD	Ahrens	54		54	73	127	3	18	5	5							1	2					5				0	148		5	Open Air	1970		48	N/A	N/A	Tromnau (1973)
Germany	Teltwisch	Teltwisch-Mitte	YD	Ahrens	1196		1196	6202	7398	144	409	270	65							22	12					40				0	7951		5	Open Air	1969	15	48	N/A	N/A	Tromnau (1973)
Germany	Teltwisch	Teltwisch-Nord	YD	Ahrens	47		47	72	119	1	15	8	1							1	1					4				0	135		5	Open Air	1970		48	N/A	N/A	Tromnau (1973)
Germany	Teltwisch	Teltwisch-Ost	YD	Ahrens	491		491	860	1351	13	116	57	12							14	17					16				0	1480		5	Open Air	1970		48	N/A	N/A	Tromnau (1973)
Germany	Teltwisch	Teltwisch-West	YD	Ahrens	83		83	624	707	8	68	39	16							2						11				0	783		4	Open Air	1969		48	N/A	N/A	Tromnau (1973)
Denmark	Eskebjerg		YD	Ahrens					12500	32	244	58	90							93						3				0	20000	7224	4	Open Air	2002	212	4	N/A	N/A	Hansen + Pedersen (2006)
Denmark	Sølbjerg	Sølbjerg I	YD	Ahrens						4	89	16	3							18						37		15		15	93		5	Open Air	1989	66	13	N/A	N/A	Petersen + Johansen (1991)
France	Boissière-Ecole		YD	LB	1022	2007	3029	3684	6713	35	208	30	29						17	125	5		1			1				0	9959	3211	7	Open Air	1953	10000	150	Non Local	Good	Valentin (1992)
UK	Robin Hood's Cave		YD	Fed					266	3	63	7	8							38						10				0	332		4	Cave	1964	4	93	N/A	N/A	Bonsall (1977)
UK	Cathole Cave		YD	Fed					107		19	7	3							6		1				2				0	126		5	Cave	1968	2	53	N/A	N/A	Bonsall (1977)
UK	Sun Hole Cave		YD	Ahrens					34	1	8	1	1							5						1				0	43		4	Cave	1968	4	84	N/A	N/A	Bonsall (1977)
Germany	Borneck	Borneck-Ost	YD	Ahrens	650		650	1000	1650	29	80	35	5							15			5			4				16	1759		6	Open Air	1950's	60	44	N/A	N/A	Kotthaus (2013)
Germany	Borneck	Borneck-Nord	YD	Ahrens	100		100	450	550	9	27	4	5							1	11	3	1			1				1	586		8	Open Air	1950's	25	44	N/A	N/A	Kotthaus (2013)
Germany	Borneck	Borneck-Callenhardt-Gruppe	YD	Ahrens	670		670	1600	2270	30	157	53	61							19	17									7	2457		5	Open Air	1950's	120	44	N/A	N/A	Kotthaus (2013)
Germany	Pinnberg	Kulturschicht 1a	YD	Ahrens					100	20	82	23	15							4	25						15			15	202		5	Open Air	1950's		12	N/A	N/A	Rust (1958)
Germany	Pinnberg	Kulturschicht 1b	YD	Ahrens	500		500	3500	4000	95	365	10	180							20	51	6					85	10		98	4460		6	Open Air	1950's		12	N/A	N/A	Rust (1958)
Germany	Stellmoor		YD	Ahrens	603		603	812	1415	66	107	8	30							44	8							17		17	1588		5	Open Air	1940's		32	N/A	N/A	Rust (1943)
Netherlands	Geldrop	Geldrop/Mie Peels	YD	Ahrens	285		285	1513	1798	16	74	4	6				1		9		32		2							20	1980	92	7	Open Air	1985	110	20	Local	Variable	Deeben + Schreurs (2012)
Netherlands	Hoogkerk		Unknown	Ahrens	15		15	20	35	11	2																	2		2	51		1	Open Air	2000	25	-1	Local	Poor	Niekus (2004)
Netherlands	Someren		Unknown	Ahrens	11		11	3	14	1	6									2								4		4	21		2	Open Air	1952	8000	24.75	Non Local	N/A	Arts + Deeben (1977)
Netherlands	Geldrop	1	YD	Ahrens	86		86	407	493	7	91	16	8	1			4		6	46			3							7	680	89	8	Open Air	1950's		20	N/A	N/A	Drenth (2015)
Netherlands	Geldrop	2	YD	Ahrens	44		44	15	59	9	148	38	34	1			3		13	51			3							5	234	18	8	Open Air	1950's		20	N/A	N/A	Drenth (2015)
Netherlands	Geldrop	3-1	YD	Ahrens	383		383	117	500	25	260	61	29	1			7		42	88			7							25	865	80	8	Open Air	1960's		20	N/A	N/A	Drenth (2015)
Netherlands	Geldrop	3-2 East	YD	Ahrens	1218		1218	3171	4389	45	392	54	31	4			11		62	133			1							96	5549	723	8	Open Air	1960's	88	20	N/A	N/A	Drenth (2015)
Netherlands	Geldrop	3-3	YD	Ahrens	244		244	532	776	4	33	1	6	1					2	9										14	914	101	6	Open Air	1970's		20	N/A	N/A	Drenth (2015)
Netherlands	Vessem Rouwven		YD	Ahrens	2624		2624	4427	7051	26	772	110	67	6			4		27	274			5				85	184		279	8298	449	8	Open Air	1970's		20	N/A	N/A	Drenth (2015)
Germany	Ziegenberg		YD	Ahrens	275	29	104	164	278	11	117	79	20		3					7			2							6	630	224	6	Open Air	1980's		317	N/A	N/A	Floss (1989)
France	Notre-Dame-de-l'Isle		YD	Ahrens	12	3	15	41	56	5	3																	1		3	99	35	1	Open Air	1998	5	19	Local	Medium	Biard + Prost (2015)
France	Guerny		YD	Ahrens	9	2	11	28	39	5																				0	57	13		Open Air	1999	3	N/A	Local	Good	Biard + Prost (2015)
Germany	Gemarkung Rockstedt		YD	Ahrens	1281		1281		1281	69	158	102	34							7				10	3					2	1508		7	Rockshelte	1944		7	N/A	N/A	Von Heinrich Maack (1977)
Germany	Hofer		YD	Ahrens	681		681	830	1511	9	35	5	6							7	2		3			10				2	2888	1331	7	Open Air	1986	150	62	N/A	N/A	Veil (1987)
Germany	Reingsen		YD	Ahrens	170		170	1953	2123	250	127	15	19							50	3									40	2500		5	Open Air	1981	150	240	Non Local	Good	Blank (1985)
Belgium	D'Engis		YD	Ahrens	29	6	35	1	36	1	7		1						3	1	1									1	94	49	5	Cave	1896	20	109	N/A	Good	Dewez (1987)
Belgium	Fonds-de-Foret		YD	Ahrens	233	184	417		417	40	105	14	3				3		55	14	6									10	2248	1686	7	Cave	1920	300	117	N/A	N/A	Dewez (1987)
Belgium	Remouchamps		YD	Ahrens	347	215	562	3599	4161	5	96	11	9	1	1		3	3	45	16	7							8	1	0	4267	5	9	Cave	1969	10	142	N/A	N/A	Dewez (1987)
Belgium	Coléoptère	Niveau A	YD	Ahrens						4	12																			0	17			Cave	1923	20	149	N/A	N/A	Dewez (1987)
Belgium	La Préalle		YD	Ahrens	11	3	14	8	22	4	7									7								1		0	34	1	1	Cave	1921	8	180	N/A	Good	Dewez (1987)
Germany	Melbeck		YD	Ahrens	522		522	467	989	15	0																			0	2475	1571		Open Air	1990	4	20	N/A	N/A	Richter (1992)
UK	Three Ways Wharf	Scatter A	YD	LB	244		244	352	596	12	33	1									9			1		9				13	932	291	5	Open Air	1987	66	31.4	Local	Poor	Lewis + Rackham (2011)
UK	Three Ways Wharf	Scatter C East	YD	LB	1164		1164	1434	2598	42	215	35	15				7				31		5	8		48				66	5866	3011	8	Open Air	1987	816	31.4	Local	Poor	Lewis + Rackham (2011)
Netherlands	Enterse Akkers		YD	Fed	65		65	537	602	2	42	9	7	1					3	11										11	1102	456	6	Open Air	2002	74	11	Local	Variable	Deeben et al. (2006)

Northwest European PB Assemblage Data

Country	Site Name	Assemblage Nam	Climate	Culture	Bl	B'lets	B + B'lets	F	Bl	C	T	ES	Bu	Bo	SP	Axe	No	Den	Trun	P	ML	Mbu	MF	Other	Kn	Saw	Awl	RF	RB	RB'lets	TR	TA	Waste	NTAXA	Site Type	Ex Year	Area (m2)	Altitude	RMS	RMQ	Sources
France	Flamanville	Flamanville	Preboreal	Unknown	339	3054	3393	6521	9914	92	831																				0	23701	15550					74			Lefevre (1994)
UK	Greenham Farm + Faraday Road		Mesolithic	E. Meso	518	233	751	1974	2725	163	474	53	5				19	6	9		112			170							100	4918	1556	8	Open Air	1997	71	104			Elis et al. (2003)
UK	Hengistbury Head	Mesolithic Site	Mesolithic	E. Meso	6270		6270	6949	13219	187	686	95		1				65	15		390			60							60	37594	21933	7	Open Air	1984	11	11	Local		Barton (1992)
UK	Star Carr		Mesolithic	E. Meso	0			15481	15481	167	2496	446	336	114		7			48	2	248		9	7				1279			1279	18144		10	Open Air	1949		25	Local	Good	Clark (1971)
UK	Three Ways Wharf	Scatter C West	Mesolithic	E. Meso	1935		1935	2126	4061	62	333	96	6			4	10				48		2	73							94	9544	5088	8	Open Air	1987	816	8	Local	Poor	Lewis + Rackham (2011)
Netherlands	Neerharen-De-Kip		Mesolithic	E. Meso	656		656	442	1098	29	145	16	1		1					41				47					6	27	39	2765	1522	6	Open Air	1979	40	41	Local	Poor	Laumers (1982)
Belgium	Schulen	Schulen 1	Mesolithic	E. Meso				2228	2228	36	315	49	22	4						47	11			172				55	31	76	10	9678	7099	7	Open Air	1977		21		Good	Huyge + Vermeesch (1982)
Belgium	Schulen	Schulen II	Mesolithic	E. Meso				135	135		29	1	3							5	2							10		8	18	555	391	5	Open Air	1978	39	21		Good	Huyge + Vermeesch (1982)
Belgium	Schulen	Schulen III	Mesolithic	E. Meso				901	901	9	243		3	4						21				133				35	5	34	82	3326	2173	5	Open Air	1978	125	21		Good	Huyge + Vermeesch (1982)
Belgium	Schulen	Schulen IV	Mesolithic	E. Meso				242	242	4	65	4	1							9				27				8	1	12	24	1126	815	5	Open Air	1979		21		Good	Huyge + Vermeesch (1982)
France	Haute-Borne		Preboreal	E. Meso	216	1397	1613	1709	3322	124	393	32	2	13	2				28		115			83				24	23	71	118	5782	2000	8	Open Air	1908	100	85	Non Local	Good	Fagnard et al. (1981)
Denmark	Barmose	Barmose I	Preboreal	Maglemoseian					15000	88	1821	65	84	24		39		40			72		1	1028							468	20648	3739	9	Open Air	1967	95	2			Johansson (1990)
Denmark	Hasbjerg	Hasbjerg II	Preboreal	Maglemoseian					6000	55	651	19	38	4		14		19			83			321					22		153	8056	1350	8	Open Air	1980's		3			Johansson (1990)
Denmark	Rormyr	Rormyr II	Preboreal	Unknown					443	11	170		13	3		2			6		59			87								624		6	Open Air	1960	140	146	Non Local		Skar + Coulson (1989)
France	D'Acquigny		Mesolithic	E. Meso			1237	1961	3198	190	504	19	7		1					179	180			4				55	38	21	114	4057	165	7	Open Air	1979	69	15	Local	Good	Souffi (2004)
Belgium	Sougné-Remouchamps	Sougné A	Mesolithic	E. Meso					78		606	55	13	6						235	111			13				52	121		173	86000		7	Open Air	1975	101	142	Local	N/A	Votquenne (1994)
Belgium	Le Spinoi		Mesolithic	E. Meso	57	113	170	7	177	44	31	11								7	13											768	476	3	Open Air	1993	100	73	Local	High	Bosquet et al. (1994)
Belgium	Zonhoven-Kapelberg		Mesolithic	E. Meso					1153	6	70	5	6							33											26	1841	572	4	Open Air	1984	56	57			Huyge (1985)
Belgium	Donk		Mesolithic	E. Meso			575	552	1127	29	83	10	11	2							48										12	1244	5	5	Open Air	1984	193	25			Vynicker + Vermeersch (1985)
UK	Brixworth	Site 24	Mesolithic	E. Meso				393	393	143	338	36		9							6								266		287	906	32	4	Open Air	1990	5150	120	Local	Variable	Ford (1995)
UK	Brixworth	Site 27	Mesolithic	E. Meso				632	632	228	396	20									10								366		366	1256		3	Open Air	1990	5150	120	Local	Variable	Ford (1995)
Netherlands	Wachtebeke	Oostdonk	Mesolithic	E. Meso					428	15	38	11	11							5	11											549	68	4	Open Air	1983		6			Ameels + Van Vlaenderen (1995)
Netherlands	Wachtebeke	Overlede	Mesolithic	E. Meso							40	18	15								7											549		3	Open Air	1983		6			Ameels + Van Vlaenderen (1995)
Netherlands	Wachtebeke	Kalve	Mesolithic	E. Meso					527	19	59	12	23							5	9	5	5									641	36	6	Open Air	1983		6			Ameels + Van Vlaenderen (1995)
Netherlands	Wachtebeke	Overslagdijk	Mesolithic	E. Meso					379	9	21		14								7											464	55	2	Open Air	1983		6			Ameels + Van Vlaenderen (1995)
Belgium	Moerbeke	Koudenborn	Mesolithic	E. Meso					354	19	62	15	22							22	3											482	47	4	Open Air	1983		235			Ameels + Van Vlaenderen (1995)
Germany	Pinnberg	Kulturschicht III	Mesolithic	E. Meso	200		200	1000	1200	31	147	50	30	3		10				4	23							20	7		27	1378		7	Open Air	1950's		12			Rust (1958)
France	Crouy	Étang	Mesolithic	E. Meso	72		72	292	364	44	15	4								6		2	2								1	521	101		Open Air	1990's		11	Local	Good	Unknown PhD, University of Lille (1999)
France	Etangs de la Brenière		Preboreal	E. PB			1842	2931	4773		550	16	13				5	4	31		67	121	121					85	60	27	172	7826	2476	9	Open Air	1953	120	19	Local	High	Unknown PhD, University of Lille (1999)
France	Fumichon		Mesolithic	E. Meso	171	714	885	496	1381	50	185	22	2	9		21		7	22	34				17				22		29	51	2119	473	9	Open Air	1970's		133	Local	Good	Ghesquière et al. (2012)
France	Hangest	Étang	Mesolithic	E. Meso	91		91	192	283	27	19	3								6	8										2	451	121		Open Air	1990's	10	9	Local	Variable	Unknown PhD, University of Lille (1999)
France	Hangest	Gravière II 3	Mesolithic	E. Meso	148		148	575	723	54	111	94								12	2										3	1221	333		Open Air	1990's	5	9	Local	Variable	Unknown PhD, University of Lille (1999)
France	Hangest	Grdvière II Nord	Mesolithic	E. Meso	884		884	3502	4386	277	267	40								85	99										43	7775	3231		Open Air	1990's	40	9	Local	Variable	Unknown PhD, University of Lille (1999)
France	La Gorgeon-des-Rues		Mesolithic	E. Meso	111	174	285	320	605	47	53	4		1	1			2		18				13							22	1473	768	7	Open Air	2004	120	8	Local	Good	Prost (2013)
France	Vingt-Deux Boisselées	I	Mesolithic	E. Meso	58	619	677	506	1183	60	211	2	1					2	4	62		61	61	0							18	1888	431	9	Open Air	1997	4	35	Non Local	Medium	Michel (2011)
France	Maroilles		Mesolithic	E. Meso	225	102	327	344	671	20	146	29	1	8			15		31	3	1	5	5	3				31	14		45	1470	639	11	Open Air	1978	132	134	Local	Poor	Fagnart (1979)
France	Pen Hoat Salaiin	US 3	Mesolithic	Bertheaume	94	664	758	4002	4760	140	364	31		1	1		1	9	1	291				22							7	16293	11045	9	Open Air	2007	200	75			Nicolas et al. (2012)
France	Quillien	201	Mesolithic	Bertheaume	66	911	977	1090	2067	271	395	60	1	3	5				18		17			22				104	17	148	269	6790	3994	8	Open Air	1980	50000	210	Non-Local	High	Gouletquer + Leopold (1991)
France	Quillien	202	Mesolithic	Bertheaume	6	69	75	155	230	57	103	6	1		3				3					4				47	11	28	86	578	189	6	Open Air	1980	50000	210	Non-Local	High	Gouletquer + Leopold (1991)
Belgium	Toul-an-Naouc'h		Mesolithic	Bertheaume	7	145	152	701	853	11	54							1	1		36							8		8	16	918		4	Open Air	1989		1			Kayser et al. (1990)
Belgium	Trou Al'Wesse	4b	Mesolithic	E. Meso					2078		101	2	1				5			26	33	6						10	3	15	28	2178		8	Cave	2003	88	197	Local		Miller et al. (2007)
Belgium	Arendonk Korhaan	Zone 4	Mesolithic	Uknown	1	15	16	54	70	1	2						1			1												139	66	2	Open Air	2003		31			Vanmontfort et al. (2010)
Belgium	Holsbeek	Marrant	Mesolithic	E. Meso	164	865	1029	5157	6186	341	974	244	39	23		17	34		62	37	51	14	14	200				126	22	24	239	7501		12	Open Air	1947		13			Vermeersch (1972)
Belgium	Holsbeek	Boomkwekerij	Mesolithic	E. Meso	362	1199	1561	7580	9141	381	1147	208	31	38		25	100		86	52	23	20	20	267				132	20	40	277	10669		12	Open Air	1947		13			Vermeersch (1972)
Belgium	Verrebroek Dok 1	C70	Mesolithic	E. Meso		519	519	1130	1649	22	283	59	2	2							126	18	18	28				10	20		30	26223	22375	8	Open Air	1992	62.5	0	Local	Poor	Beugnier + Crombe (2005)
Belgium	Verrebroek Dok 1	C23	Mesolithic	E. Meso		185	185	256	441	8	90	12	2								29	15	15	8				4	5		9	2928	2344	7	Open Air	1992	26	0	Local	Poor	Beugnier + Crombe (2005)
Belgium	Verrebroek Dok 1	C24	Mesolithic	E. Meso		44	44	91	135		6	4																			2	147	6	2	Open Air	1992	16.25	0	Local	Poor	Beugnier + Crombe (2005)
Belgium	Verrebroek Dok 1	C6	Mesolithic	E. Meso		97	97	313	410	11	113	1	16								36	17	17	7				4	15		19	4710	3537	7	Open Air	1992		0	Local	Poor	Perdaen et al. (2008)
Belgium	Verrebroek Dok 1	C16	Mesolithic	E. Meso		103	103	300	403	5	33	1									22	3	3	3					1		1	3152	2662	6	Open Air	1992		0	Local	Poor	Perdaen et al. (2008)
Belgium	Linkhout-Kampbergen		Mesolithic	E. Meso			21	45	66	4	61	7	2	11			2		5		5							22	7		29	326	128	7	Open Air	1930's		23		Good	Vermeersch + Carlous (1975)
Belgium	Evergem De Nest		Mesolithic	E. Meso							127	14	1	1							84							9	18		27	2180	N/A	5	Open Air	2000's		6	Local	Poor	Crombe + Beugneir (2013)
Belgium	Ede Kernhem		Mesolithic	E. Meso							654	35		4							514			6				56	39		95	10651	N/A	5	Open Air	2000's		14	Local	Poor	Crombe + Beugneir (2013)
Belgium	Doel	C3	Mesolithic	E. Meso							70	3									41							6	20		26	2584	N/A	3	Open Air	2000's		0	Local	Poor	Crombe + Beugneir (2013)
Belgium	Doel	C2	Mesolithic	E. Meso		69	69	384	453	12	60	7	3								9			12				4		7	29	671	143	5	Open Air	2000's		0	Local	Poor	Crombe + Beugneir (2013)
Netherlands	Oudega		Preboreal	Epi-Ahrens	109		109	66	175	4	29	8	2	1			1		2	12				2					1		1	244	36	8	Open Air	1971		-1	Non Local	High	Niekus + Stapert (1994)
Netherlands	Zutphen-Ooijerhoek	Site M	Mesolithic	E. Meso	19		19	115	134	9	17	1	3								8								4		5	244	84	4	Open Air	2000		7	Local	Poor	Groenewoudt et al, (2001)
Netherlands	Lageland		Mesolithic	E. Meso	36		36	42	78	7	20	1				3			1		7	3	3					2			2	235	106	7	Open Air	1996	2400	-3			Niekus et al. (1997)
Netherlands	Havelte	H1: III	Mesolithic	E. Meso	141		141	1363	1504	43	27	10								5	2				1			6	3		9	1982	408	5	Open Air	1970	225.5	3	Local	Variable	Price et al. (1974)
Netherlands	Havelte	H2: II	Mesolithic	E. Meso	423		423	4203	4626	129	182	26	2	4						33	43				14			46	14		60	6310	1373	7	Open Air	1970	367.75	3	Local	Variable	Price et al. (1974)
Netherlands	Havelte	H2: I	Mesolithic	E. Meso	500		500	6529	7029	250	287	66	6	24						44	19				22			90	16		106	9925	2359	7	Open Air	1970	367.75	3	Local	Variable	Price et al. (1974)
Germany	Friesack	27a	Mesolithic	E. Meso	245		245		245	112	112	47	18	2							36										9	1693	1224	5	Open Air	1977	38	44			Gramsch + Kloss (1990)
Netherlands	Posterholt		Mesolithic	E. Meso					1260	27	144	3	3								61	31	31								15	6000	4600	6	Open Air	1993	36	32	Local	Good	Verhart (1995)
Netherlands	Maasvlakte	Maasvlakte 2	Mesolithic	E. Meso	144		144	706	850	22	130	15	16	2	1		2				34	10	10	2							38	2976	1754	10	Open Air	2011	376	-22	Non Local	Good	Moree + Sier (2015)
Norway	Mohalsen	Mohalsen-II	Mesolithic	E. Meso	5		5	301	306	23	16	4	3								1							8			8	345	N/A	4	Open Air	2012	35	75	Local	Poor	Bjerck et al. (2012)
UK	Misterton Carr		Mesolithic	Maglemoseian	666		666	3735	4401	467	677	228	32			5			4		72	5	5		3	14	7	302			302	6287	742	11	Open Air	1971	500	5	Local	Poor	Buckland (1976)
Netherlands	Geldrop	3-0	Mesolithic	E. Meso	91		91	105	196	1	23	2	1				2		3	1											14	238	18	7	Open Air	1960's		20			Drenth (2015)
Netherlands	Geldrop	3-2 West	Mesolithic	E. Meso	25		25	56	81	4	31	15	7				2		1	4											2	141	25	6	Open Air	1960's		20			Drenth (2015)
Netherlands	Venlo-Raaleind		Mesolithic	E. Meso	105		105	723	828	3	34	8					4			7								9	6		15	991	126	4	Open Air	1990's		23			Drenth (2015)
Finland	Sujala		Mesolithic	E. Meso	1837		1837	165	2002	16	446	21	25	1						55								9	313		344	6409	3522	5	Open Air	2005	74	69	Local		Koxvold (2011)
Finland	Tarhojenranta		Preboreal	E. Meso	13		13	43	56	1	10	1	1							2					1				5		5	67	N/A	6	Open Air	2000's			Local	Variable	Koxvold (2011)
France	Rosnay		Preboreal	E. Meso	45	116	161	342	503	9	289	51								27		18	18	32				143			143	1463	671	6	Open Air	2010	20	119	Non Local	Variable	Souffi et al. (2015)
France	Verseilles-le-Bas		Preboreal	Ahrens + E. Meso	55	1409	1464	2620	4084	427	1070	115	39	26	1			72	40	134	43			11				248	65	276	589	5581	N/A	10	Open Air	1979		336			Huet (1995)
Finland	Lahti		Preboreal	L. Swiderian	77		77	168	245		37	7	15	1		1				4	3			1	5							286	4	8	Open Air	1995	866	280			Takala (2003)
Netherlands	Oostwinkel	"Mostmolen"	Preboreal	E. Meso			621	1014	1635	94	118	15	21							19	22	9	9	9				4		8	14	5641	3640	8	Open Air	1997		16			Crombe (1998)
Belgium	Helchteren		Preboreal	E. Meso	54	27	81	256	337	29	146	32	12	1					8	52	11							14	13	2	30	1621	1048	7	Open Air	1972	10	74	Local	Good	Vermeersch (1974)

Northwest European Transitional Assemblage Data

Allerod/YD

Country	Site Name	Assemblage Name	Climate	Culture	B	B'lets	B+B'lets	F	Bl	C	T	ES	Bu	Bo	SP	Axes	No	Den	Trun	P	ML	Mbu	MF	Other	RF	RB	RB'lets	TR	TL	Waste	NTAXA	Site Type	Ex Year	Area (m2)	Altitude	RMS	RMQ	Source
France	Saleux	Occupation 114	A/YD	Fed					1597	41	204	21	37						9	70				48			19	19	4385	2562	6	Open Air	1993	760	35	Local	High	Coudret +Fagnart (2004)
Germany	Alt-Duvenstedt	Subsite LA 123	A/YD	Ahrens	163		163	172	335	3																			1613	1275		Open Air	1987	33	8.5			Kaiser + Clausen (2005)
Germany	Hintersee	Hintersee 24	A/YD	Unknown	69		69	316	385	11	2									2									675	277	1	Open Air	1998		10			Bogen et al. (2003)
Germany	Henauhof	Henauhof Northwest	A/YD	Unknown	22		22	37	59	6	24	3	6	2			2		1		1		2	5		2		2	97	8	9	Open Air	1980	20	584	Local	Poor	Jochim (1995)
Germany	Klein Nordende	Areal CR (davon aus E+C)	A/YD	Unknown	300		300	500	800	17	53	1	36	1					1					9		5		5	870		6	Open Air			11			Riede et al. (2010)
Germany	Klein Nordende	Areal A	A/YD	Unknown	32		32	42	74	5	61	5	17	1					4					24		10		10	150	10	6	Open Air			11			Riede et al. (2010)
Belgium	Brou		A/YD	Ahrens							195	40	51	3	11			4	10				3	52	4	17		21			9				319			Otte (1981)
Denmark	Langa	Langa I	A/YD	Bromme	412		412		412	15	59	18	14							1				7		19		19	2100	1614	5	Open Air		40	22	Local	Good	Madsen (1983)
Denmark	Lovenholm	Lovenholm Area 1	A/YD	Bromme	37		37		37		50	16	7	3						24									465	378	4	Open Air		45	33		Medium	Madsen (1983)
Denmark	Lovenholm	Lovenholm Area II	A/YD	Ahrens																0									28	28		Open Air			33		Medium	Madsen (1983)
Denmark	Stoksbjerg Bro		A/YD	Bromme					29500	400	1024	314	550							160									31000	76	3	Open Air	1976	210	30	Local		Pedersen + Petersen (2006)
Belgium	Ruien		A/YD	Unknown	202		202	219	421	18	37		1	3						7	2			12	8	4		12	3496	3020	6	Open Air	2011	220	16	Local	Medium	Crombe et al. (2014)
Belgium	Arendonk Korhaan	Zone 2	A/YD	Fed	5	2	7	41	48	2	7	2	4							1									99	42	3	Open Air	2003	2	29			Vanmontford et al. (2010)
Belgium	Arendonk Korhaan	Zone 4	A/YD	Fed	24	16	40	235	275	2	20		13	1					1						2	2		5	1080	783	4	Open Air	2003	4	29			Vanmontford et al. (2010)
Belgium	Zolder	Site 1	A/YD	Unknown	1		1	1	2	1	18	8	4						1						2	2		5	21		4	Open Air	1961	8	30			Vermeersch + Carolus (1975)
Belgium	Zolder	Site 2	A/YD	Unknown	23	15	38	75	113	15	54	20	5	1				1	4	3	3				9	8		17	245	62	9	Open Air	1962	10	30			Vermeersch + Carolus (1975)
Belgium	Zolder	Site 3	A/YD	Unknown	29	7	36	124	160	9	35	4	3						1					1	9	17		26	307	103	5	Open Air	1961	8	30			Vermeersch + Carolus (1975)
Belgium	Zolder	Site 4	A/YD	Unknown						1	6	1	4													1		1	7		3	Open Air	1961		30			Vermeersch + Carolus (1975)
Belgium	Lomel	1	A/YD	Unknown							3116	1547	661											435		473		473			3				47			Vanmontford et al. (2010)
Netherlands	Koelbroek	Site 2	A/YD	Ahrens					100		9	7																2	521	412	2	Open Air	1966-1987	24	28	Local	N/A	Deeben (2012)
Denmark	Fensmark	Fensmark B	A/YD	Bromme				2000	2000	19	64	15	45							4									2385	302	3	Open Air	1974	1625	32		Good	Fischer (2012)
France	Camp d'Auvours	Site 1	A/YD	Azilian						214	3899	267	231	29			39	9	255	6	2848		101					114	327000		10	Open Air	1970	195	84	Local	Variable	Allard (2013)
Denmark	Ramsgard	II	A/YD	Bromme						25	25																					Open Air						Sorensen (2010)
Denmark	Segebro		A/YD	Bromme						50	75																					Open Air						Sorensen (2010)
Denmark	Rundebakke		A/YD	Bromme						100	100																					Open Air						Sorensen (2010)
France	La Muette	2	A/YD	Tjongerien				1414	1414	8	18	3	2		1			2		3	1				4	2		6	1440		7	Open Air	1982		56			Hinout (1988)

YD/PB

Country	Site Name	Assemblage Name	Climate	Culture	B	B'lets	B+B'lets	F	Bl	T	C	ES	Bu	Bo	SP	Axes	No	Den	Trun	P	ML	Mbu	MF	LB	Other	RF	RB	RB'lets	TR	TL	Waste	NTAXA	Site Type	Ex Year	Area (m2)	Altitude	RMS	RMQ	Source
France	Le Bois Chenu		YD/PB	Ahrens	282	109	391	433	824	19	41	8	4				5			6			2		15		1		1	988	104	7				64			Leroy (2013)
France	Le Closeau	Locus P - Sud R.N. 13	YD/PB	Unknown	47		47	1310	1357	92	270																			2839	1120		Open Air	1994	1000	27	Local	Good	Teyssandier (2000)
Netherlands	Swalmen		YD/PB	Unknown	118		118	185	303	9	17	2	1								14									975	159	3				27			De Wildeet al. (2007)
France	Buhot		YD/PB	LB	2190		2190	1714	3904	180	160	35	19	1					2	52			1		25				25	4859	121	8	Open Air	2003	540	117	Local	High	Jacquier (2014)
France	La Fosse		YD/PB	LB	10297		10297	7970	18267	54	1194	126	71	9					101	669			5		114				99	34396	13537	8	Open Air	2007	90	69	Non Local	High	Jacquier (2014)
France	Flixecourt		YD/PB	LB							52		4						3						42				3	2300		4	Open Air	1987		9	Local	High	Fagnart et al. (1995)
France	Muette	Muette I	YD/PB	Ahrens	184		184	181	365	28	213	68	6	2			5	8	10	77					12		16	2	25	3444	2838	9	Open Air	1985		56			Hinout (1985)
France	Vigie Romaine		Epi-Pal	Unknown	343	877	1220	1943	3163	22	448	36	15	14			29	3	66	11					187	30		57	87	4778	719	9				32			Sicard-Marchand et al. (2004)
UK	Launde		YD/PB	LB	399	443	842	924	1766	60	77	7	7	1				1	13	13					14	1	16		21	2443	523	8	Open Air	1996	100	190	Local	Good	Cooper (2006)
UK	Sproughton		YD/PB	LB	280		280	3615	3895	45	74	8	5								4			6	26				25	4072	29	6	Open Air	1972		5			Wymer (1976)
Denmark	Nørregård	Nørregård VI	YD/PB	LB	991		991	0	991	61	414	11	54	14		18				3	15				199				100	3184	1718	8	Open Air	1994	49	48	Local	Variable	Sorensen + Sternke (2004)
UK	Titchwell		YD/PB	LB	367		367	126	493	40	72	37	16																19	669	32	3	Open Air	1986		0			Wymer + Robins (1994(
UK	Underdown Lane		YD/PB	LB	65		65	84	149	5	21	1	6								1				3				10	560	369	5	Open Air	2003	90	14	Local	Poor	Gardiner et al. (2007)
France	Donnemarie-Dontilly	Locus 4	YD/PB	LB	454		454	432	886	50	16	9	1							1					4		1		1	952		5	Open Air	1991	96	80	Local	High	Valentin (1992)
France	Muides-sur-Loire	Locus II	YD/PB	LB	197		197	236	433	11	10	2		1					1	2					2	1	1		2	454		6	Open Air	1993	50	90	Local	High	Hantaï (1997)
France	Muides-sur-Loire	"Clos Mailloux"	YD/PB	LB	197		197	578	775	36	22	3													18	1			1	833		3	Open Air	1993		90	Local	High	Hantaï (1997)
France	Villers-Tounelle		YD/PB	LB						1	10																			100			Open Air	1981		132		Good	Fagnart (1988)
Netherlands	Oudehaske		YD/PB	Ahrens	471		471	344	815	6	64	12	7							39					3		3		3	2649	1706	5	Open Air	1989	58	1	Non Local	Good	Stapert (1998)
Netherlands	Gramsbergen	Gramsbergen I	YD/PB	Ahrens	826		826	621	1447	18	170	43	29	1						82			2		7		6		6	2397	610	7	Open Air	1973	93	7	Non Local	Good	Stapert (1998)
Netherlands	Gramsbergen	Gramsbergen II	YD/PB	Ahrens	84		84	89	173	6	17	2	1							6					4		4		4	225	18	5	Open Air	1972		7	Non Local	Good	Stapert (1998)
Belgium	Moerbeke	Vossel	YD/PB	Epi-Pal					286	12	42	10	21							8	3									430	60	4	Open Air	1983		235			Ameels + Van Vlaenderen (1995)
Belgium	Moerbeke	Driehoek	YD/PB	Epi-Pal					567	37	67	17	30							15	5									731	30	4	Open Air	1983		235			Ameels + Van Vlaenderen (1995)
UK	Wawcott	XII	YD/PB	LB	335		335	103	438	35	7										2							5	5	972	520	2	Open Air	1965	300	86	Local	Good	Froom (2005)
UK	Crown Acres		YD/PB	LB	563		563	88	651	34	15	8	1						3	3										681		4	Open Air	1961		69	Local	Medium	Froom (2005)
Germany	Pinnberg	Kulturschicht II	YD/PB	Unknown					100	50	83	38	8			13				4	20									299	33	5	Open Air	1950's		12			Rust (1958)
France	Belloy-sur-Somme	Serie a Patine Bleutee	YD/PB	LB	1485	37	1522	2364	3886		846	27	7	3			201		2					472		98	36		134	5578		7	Open Air	1984	1590	18	Local	Good	Fagnart (1992)
France	Bois de Hannappes		YD/PB	Epi-Pal	124		124	1307	1431	19	93	24	1				8	16	1	10			1		7	9	17		25	1691	74	9	Open Air	1968		162	Local		Hinout (1992)
Netherlands	Weelde- Eindegoorheide	WEH 12	YD/PB	Epi-Pal	457		457	1460	1917	23	317	146	49	8							28		2						84	4534	1983	6	Open Air	1997	302	37			De Wildeet al. (2007)
Netherlands	Weelde- Eindegoorheide	WEH 13	YD/PB	Epi-Pal	417		417	1541	1958	23	163																			3798	1677		Open Air	1997	280	37			De Wildeet al. (2007)
UK	Gatehampton Farm		YD/PB	LB	196	41	237	392	629	10	15	2	1											4		5	3		8	841	182	4	Open Air	1985		42			Allen et al. (1995)
Lux	Remerschen-Raederbierg		YD/PB	Ahrens	56	52	108	126	234	3	25	3	3						2	3	1				8				5	981	697	7	Open Air	1999	52	150	Non Local	High	Brou (1998)
Sweden	Tosskarr		YD/PB	Hensbacka					12259	200	400	67	42			5				170		116								13259	200	5	Open Air	1950	150	52			Kindgren (2002)
UK	Church Lammas	Scatter 1	YD/PB	LB	88		88	81	169	9	25	0	2						1		1	1		13					7	631	428	6	Open Air	1995	77	14	Local	Poor	Jones (2013)
UK	Church Lammas	Scatter 2	YD/PB	LB	36		36	19	55	1	1	0	1																	71	14		Open Air	1995		14	Local	Poor	Jones (2013)

Southern European Allerod Assemblage Data

Country	Site Name	Assemblage Name	Climate	Culture	B	B'lets	B+B'lets	F	Bl	C	T	ES	Bu	Bo	SP	No	Den	Trunc	P	ML	MBu	MF	Knive	Other	RF	RB	RB'lets	TR	TL	Waste	NTAXA	Site Type	Ex Year	Area (m2)	Altitude	RMS	RMQ	Source
France	Fru à Saint-Christophe-la-Grotte	Layer 3	Allerod	Azilian							889	243	37	14	6	9		26	297					127	34	92	4	130			9	Cave	1980	21	570	Local	Variable	Pion (1997)
Spain	Balma Guilanyà	Level EJ	Allerod	Azilian							66	21			3	1	3	4	14					11		9		9			8	Rockshelter	2008	9	1150			Martínez-Moreno (2009)
Spain	La Riera Cave	Levels 21-23	Allerod	Unknown	10	69	79	300	379	6	79	11	12	4		5	7	2						30		8		8	558	94	8	Cave	1978	25	85			Straus + Clark (1986)
Spain	La Riera Cave	Level 24	Allerod	Unknown	57	324	381	2098	2479	20	218	39	14	1	1		6	3	10			2		126				16	3277	560	10	Cave	1978	25	85			Straus + Clark (1986)
Spain	La Riera Cave	Level 25-26	Allerod	Unknown	16	24	40	969	1009	11	59	8			5		6	1	3			1		30				5	1345	266	8	Cave	1978	25	85			Straus + Clark (1986)
Croatia	Vesanka Cave	Interstadial Phase 1	Allerod	Unknown	4	24	28	31	59	6	16	2	4					1	7									2	120	55	5	Cave	1997	6	195	Non-Local	High	Komso + Pellegatti (2007)
Croatia	Vesanka Cave	Interstadial Phase 2	Allerod	Unknown	6	28	34	52	86	7	30	4	4	1	1		1	2	9			1						7	220	126	9	Cave	1997	6	196	Non-Local	High	Komso + Pellegatti (2007)
Croatia	Pupicina Cave	Interstadial	Allerod	Unknown	15	38	53	135	188	10	41	13	12				2	3	7									4	380	179	6	Cave	1995	72	220	Non-Local	N/A	Komso + Pellegatti (2007)
Croatia	Nugljansk Cave	Interstadial	Allerod	Unknown	8	7	15	41	56	1	18	5	1			2			3									7	79	22	5	Cave	1998		550	Non-Local	N/A	Komso + Pellegatti (2007)
Croatia	Kopa cina Cave	IV	Allerod	Unknown	43	10	53	240	293	25	40																		1543	1234		Cave	1978	55	280	Local	Variable	Vukosavljević + Perhoč (2017)
France	Abri Dufaure	Stratum 4	Allerod	U. Mag					9458		2051	226	532	61				79	1153									0	48226	36232	5	Rockshelter	1980	30	3			Straus (1987)
France	Abri Dufaure	Stratum IV	Allerod	U. Mag					3401		650	56	160	17				46	371									0	15590	11452	5	Rockshelter	1980	23	3			Straus (1987)
France	Saint-Antoine	Locus 2	Allerod	F. Epigrav			6733	984	7717	303	2671	199	5		12	9		7	2413									26	13596	5576	7	Open Air	1996	50	575	Non-Local	Good	Bracco et al. (1997)
Italy	Val Lastari		Allerod	F. Epigrav	743	718	1515	1191	2706	419	501	52	57	2				21	312			2			9	37	9	55	3745	620	7	Open Air	1990	90	1060	Local	High	Broglio (1994)
France	Saint-Antoine	Locus 1	Allerod	F. Epigrav			1120	635	1755	124	704	44	3	2		6		8	619			1			14	6		20	2582		9	Open Air	1967	50	250			Bracco et al. (1997)
Italy	Villabruna	Abri A	Allerod	F. Epigrav						33	186	64	7	2			2	1	87	2		4	7		0	10		10			10	Rockshelter	1987	25	520			Montoya (2008)
Italy	Villabruna	Abri C	Allerod	F. Epigrav						5	34	4	1						28				1		0			0			4	Rockshelter	1987	8	520			Montoya (2008)
Italy	Riparo Dalmeri		Allerod	F. Epigrav						204	3211	320	283					230	1628		140				0	368		368			6	Rockshelter	1991	60	1240	Local		Montoya (2008)
Italy	Grotta del Clusantin		Allerod	F. Epigrav					639	12	482	38	6	4					320		85		5		15			24	1856	719	7	Cave	2001	15	520	Non-Local	High	Peresani et al. (2009)
Italy	La Greppia II	US 1	Allerod	F. Epigrav	1129		1129	1543	2672	286	217	32	1	3			17	7	141						4	12		16	30335	27160	7	Open Air	2003	20	1185	Local	Good	Dini + Sagramoni (2005)
Italy	Abri Soman	Unit 161	Allerod	F. Epigrav						55	629	76	6	6			3	16	463	10	18	6	8	1		16		16			12	Rockshelter			100			Battaglia + Lanzinger (1994)
Italy	Tchonstoan Rockshelter		Allerod	L. Epigrav	12	51	63	16	79	1	58	1			1		0	0	43		6		1					6	158	20	6	Rockshelter	1986	15	1870	Non-Local	Good	Avanzini et al. (1997)
Spain	Balma Guilanyà	Level E	Allerod	Azilian							122	27	1		4		18	2	36							34		34			7	Rockshelter	2008	9	1150			Martínez-Moreno + Torcal (2009)
Spain	Barroberría	Level E Superior	Allerod	F. Mag	12		12	109	121	3	29	4	4	2	1	5	1		3					4	4	1		5	153		9	Cave	1977	200	156			Barandiar (1979)
Spain	Cova Gran	S4B	Allerod	F. Mag					1000		95	22	5		1		7	1	33	29								0	1102		7	Cave	2005	32	360			Bolivar et al. (2012
Spain	Cova Gran	S4C	Allerod	F. Mag					610		107	33	16		1		6	3	22	26								0	726		7	Cave	2005	32	360			Bolivar et al. (2013
Spain	Covarxelles		Allerod	E. Epigrav	47	76	123	372	495	25	150	36	2	1	3		18	29	5	31	1	7						7	1212	658	11	Open Air	2007	55	750			Monroig (2012)
Spain	El Mirador	MIR51/2	Allerod	FUP				1520	1520	13	10	1	0			1									8			8	3072	1529	3	Cave	1999	6	1030			Verges et al. (2016)
Spain	Hort de la Boquera	Level 2	Allerod	FUP				14534	14534	269	783	227	17				69	55	337					65				13	2E+05	225645	7	Rockshelter	1990	20	368	Local		Andreu et al. (2014)
Spain	Mallada Cave		Allerod	F. Mag				1390	1390	22	135	44	26		12	1	13		30			5		4					1662	121	8	Cave	1953	12	66			Catalan + Rodriguez (2015)
Spain	Areny		Allerod	Epi Mag				1235	1235	30	163	67	4		10		23	3	46			4		6					2003	575	8	Rockshelter	1958	4	175			Catalan + Rodriguez (2015)
Spain	Martinarri	Level 103	Allerod	F. Mag					1250	7	42	9	2				2	3	26										1300		5	Rockshelter	2007	2	807	Non-Local		Alday et al. (2012)
Spain	Peña de Estebanvela	Level I	Allerod	F. Mag			160	692	852		156	58	3	5				7	72						11	4		15	1595	587	6	Rockshelter	1999	9	1085			Quesada et al. (2004)
Spain	Peña de Estebanvela	Level II	Allerod	F. Mag			1794	2890	4684		276	88	5					11	129						24	19		43	11380	6420	5	Rockshelter	1999	7	1085			Quesada et al. (2004)
Spain	Picamoixons	CNP	Allerod	F. Mag			N/A	79	79	1	8	1			2		4	1											89	2	4	Open Air	1993	4	260			Catalan et al. (2009)
Spain	Roureda	Level 2	Allerod	Epi Mag	274	444	718	1665	2383	16	286	25	9	3	3		30	50	3	105	1	5		29				23	4639	2006	12	Rockshelter	2007	2	1150	Non-Local	High	Monroig (2010)
Spain	Cala Cubanita		Allerod	F. Mag	5	25	30	268	298	9	35	6				2	2	7	15					3					619	271	6	Cave		50	2			Monroig (2010)
Spain	Zatoya	Iib	Allerod	F. Mag					506	20	91	33	10	1	1		3	3	40					0					638	21	7	Cave	1980	99	900			Barandiarán + Cava (2001)
Spain	Urtiaga	D2	Allerod	F. Mag							719	203	262	7	2		58	14	145			16		12							9	Cave	1954		1025			Barandiarán + Cava (1989)
Spain	Urtiaga	D3	Allerod	F. Mag							355	84	156	4	3		27	17	52			9		3							9	Cave	1954		1025			Barandiarán + Cava (1989)
Spain	Ekain	Level V-IV	Allerod	F. Mag							224	35	48	2			12	6	120					1							7	Cave	1969		89			Barandiarán + Cava (1989)
Spain	Ekain	Level VI	Allerod	F. Mag							385	57	88	2			12	8	198			14		6							8	Cave	1969		89			Barandiarán + Cava (1989)
Spain	Aitzbitarte IV	II	Allerod	F. Mag						8	425	125	100	4			55	34	63			17		10							8	Cave	1960	6	310			Barandiarán (2014)
Spain	Poeymaü	BI	Allerod	F. Mag							172	64	2				51	19	30					6							6	Cave	1948		647			Barandiarán + Cava (1989)
Spain	Poeymaü	Level 7	Allerod	F. Mag							66	32	5		1		18	4	4					2							7	Cave	1948		647			Barandiarán + Cava (1989)
Spain	Kukuma		Allerod	F. Mag							46	2	3				6	0	22	3				10							6	Cave			744			Soto et al. (2015)

Southern European YD Assemblage Data

Country	Site Name	Assemblage	Climate	Culture	B	B'lets	B+B'lets	F	Bl	C	T	ES	Bu	Bo	SP	No	Den	Trunc	P	ML	MBu	MF	Knives	Other	RF	RB	RB'lets	TR	TL	Waste	NTAXA	Site Type	Ex Year	Area (m2)	Altitude	Predomina	Raw Mate	Source
Spain	La Riera Cave	Level 27	YD	Unknown	46	65	111	1566	1677	54	108	22	8	2	6	8	8		12					39				3	2553	714	9	Cave	1978	25	85			Straus + Clark (1986)
Croatia	Pupicina Cave	Younger Dryas	YD	Unknown	12	37	49	127	176	8	43	13	11	2	1	4		1	5			2						4	365	181	9	Cave	1995	72	220	Non-Local		Komso + Pellegatti (2007)
Croatia	Nugljansk Cave	Younger Dryas	YD	Unknown	16	16	32	57	89	9	13	2	2						5									4	155	58	4	Cave	1998		550	Non-Local		Komso + Pellegatti (2007)
Croatia	Šandalja II	B/d	YD	F. Epigrav	125	164	289	827	1116	65	350	80	11	19	7	20	11	73	65					28				36	1776	256	10	Cave			70	Check	Check	Janković et al. (2012)
Croatia	Šandalja II	B/s	YD	F. Epigrav	269	530	799	2223	3022	239	814	152	24	34	47	32	18	148	142	26				70				121	5406	1329	11	Cave			70	Check	Check	Janković et al. (2012)
Croatia	Šandalja II	B/g	YD	F. Epigrav	118	224	342	880	1222	92	422	83	9	28	1	17	8	70	78	16				27				85	2351	600	11	Cave			70	Check	Check	Janković et al. (2012)
France	Fru à Saint-Christo	Layer 4c	YD	Azilian							54	4						1	2	28	12				7			7			6	Cave	1980	6	570	Local	Variable	Pion (1997)
France	Abri Dufaure	Stratum 3	YD	Azilian					2542		277	49	56	2				6	164									0	12486	9624	5	Rockshelte	1980	55	3			Starus (1987)
Italy	Palù Echen		YD	F. Epigrav					1139	13	116	19	19	6				4	27		30	2		4	2	3		5	1268		9	Open Air	2004	30	1260	Non-Local	High	Dalmeri et al. (2013)
Italy	Palughetto	MN	YD	T. Epigrav					1243	72	142	27	15	4				8	54	21					7	6		13	2420	959	7	Open Air	1993	91	1089	Local	Medium	Peresani et al. (2011)
Italy	Palughetto	MO	YD	T. Epigrav					186	8	23	3	1					1	14	3			1						217		6	Open Air	2002	91	1089			Peresani et al. (2011)
Italy	Pian delle More		YD	T. Epigrav					162	10	18	10	1					3	3						1			1	190		5	Open Air	1975		1193		Good	Duches set al. (2007)
Italy	Riparo Cogola	US 19	YD	T. Epigrav					13296	34	556	66	19	5		1	9	44	354	21			3	13	5	16		21	29310	14424	11	Open Air		9	1209			Cusinato et al. (2004)
Italy	Abri Soman	Unit 131-132	YD	T. Epigrav						27	279	39	6	1	2		2	9	193	2	11			2		12		12			11	Cave			1528			Battaglia + Lanzinger (1994)
Spain	Berroberría	Level D Inferior	YD	Azilian				199	199	3	38	5	4	3		7			8					2	7	2		9	240		7	Cave	1977	200	156			Barandiar (1979)
Spain	Cingle de l'Aigua		YD	L. Epi Mag	129	442	571	1497	2068	71	419	62	6	2	6	29	17	28	19	167	11	1		9				32	5193	2971	13	Rockshelte	2006	4	750			Roman (2010)
Spain	Clot de l'Hospital		YD	L. Epi Mag	107	12	119	189	308	9	158	44	3	1	2	15		14	4	42		1						31	470		10	Rockshelte	1996	2	550			Argilagós et al. (2015)
France	Les Eglises	Level 9	YD	L. Mag	29	242	271	639	910	8	49	6	14		5				4					2		1	15	18	1077	27	6	Cave	2015	20	960			Griffin (2015)
France	Les Eglises	Level 8	YD	L. Mag	18	83	101	183	284	2	23	4	6		3									1				9	309	6	5	Cave	2015	20	960			Griffin (2015)
France	Les Eglises	Level 6	YD	L. Mag	375	509	884	1180	2064	22	127	21	33	2	9				12					14				36	1937	36	7	Cave	2015	20	960			Griffin (2015)
France	Les Eglises	Level 4	YD	L. Mag	3	9	12	36	48		3								2									1	55	4	2	Cave	2015	20	960			Griffin (2015)
Spain	Balma del Gai	Level 1	YD	LUP							177	87	3						62	7								18			5	Rockshelte	1994	50	760	Non-Local	Good	Garcia-Argüelles (2009)
Spain	Pena del Diablo I	Level 1	YD	Unknown	48	89	137	430	567	1	25	2	7			1	1		14										593		5	Rockshelte	1994	53	700			Utrilla + Domingo (2003)
Spain	Pena del Diablo I	Level 2	YD	Unknown	277	560	836	2184	3020	21	91	16	28	1		3			41			2							3132		6	Rockshelte	1994	53	700			Utrilla + Domingo (2003)
Spain	Pena del Diablo I	Level 3	YD	Unknown	36	58	95	349	444		20	4	9				1		4			2							464		5	Rockshelte	1994	53	700			Utrilla + Domingo (2003)
Spain	Pena del Diablo 2		YD	Unknown	74	41	115	298	413		14															14		14	427		1	Rockshelte	1994	30	700			Utrilla + Domingo (2003)
Spain	Las Forcas	11-12	YD	Azilian						11	37	14	5			2	1		10							5		5		1	6	Rockshelte	1990	12	450	Local	High	Utrill + Mazo (1991)
Spain	Las Forcas	10	YD	Azilian						1	31	12	5	1		3	3		5							6		6		2	7	Rockshelte	1990	12	450	Local	High	Utrill + Mazo (1991)
Spain	Diablets	Level 1	YD	Unknown	21	2	23	42	65	4	17	8						3	4			1		1					81		5	Cave		70	450			Monroig (2010)
Spain	Urtiaga	D1	YD	Azilian							481	103	109	9	1		25	6	220			4		4							9	Cave	1954		1025			Barandiarán + Cava (1989)
Spain	Ekain	Levl III	YD	Azilain							256	35	19	2			5	6	184					5							7	Cave	1969		89			Barandiarán + Cava (1989)
Spain	Zatoya	II	YD	Azilain					4220	116	434	110	39	4	5		23	13	256			6		5					4848	78	9	Cave	1980	10	900			Barandiarán + Cava (2001)
Spain	Balma Margineda	c6b	YD	Unknown							208	40	7	1	13		16	16	87	15				13							9	Rockshelter		135	970			Martínez-Moreno et al. (2006)
Spain	Portugain	Level I	YD	Azilian							441	41	59				79		129					132					38756	37220	5	Cave		100	769			Barandiarán + Cava (1986)
Spain	Pena 14	d	YD	Azilian							213	51	9				44		42	12				55							6	Rockshelte	1999	10	700			Montes (2002)
Spain	Berniollo		YD	Unknown					1282	63	269	80	22					41	77						49			49	4025	2411	5	Open Air	1970	55	538	Non-Local	Variable	González + Ibáñez (1991)
Spain	Filador	8-9	YD	Unknown						43	209	35	4				11		120					39					7327		5	Rockshelte	1973	26	350			Andreu et al. (2005)

Southern European PB Assemblage Data

Country	Site Name	Assemblage	Climate	Culture	B	B'lets	B+B'lets	F	Bl	C	T	ES	Bu	Bo	SP	No	Den	Trunc	P	ML	MBu	MF	Knive	Othe	RF	RB	RB'lets	TR	TL	Waste	NTAXA	Site Type	Ex Year	Area (m2)	Altitude	RMS	RMQ	Source
Spain	Balma Guilanyà	Level C	Preboreal	Unknown							93	10			9	18	35		2							19		19			6	Cave	2008	9	1150			Martínez-Moreno + Totcal (2009)
Spain	La Riera Cave	Level 28	Preboreal	Unknown	8	39	47	495	542	6	31	1	3		1	1	2		4					18				1	832	253	8	Cave	1978	25	85			Straus (1986)
France	Fru à Saint-Christophe-la-Grotte	Layer 4a	Preboreal	E. Meso							202	26	3					2	11	69	25				66			66			7	Cave	1980	6	570	Local	Variable	Pion (1997)
France	Fru à Saint-Christophe-la-Grotte	Layer 4b	Preboreal	E. Meso							309	15	1					1	5	164	84				39			39			7	Cave	1980	6	570	Local	Variable	Pion (1997)
Italy	I.N.F.S.		Preboreal	E. Meso					3116	13	140	13	4			7		14		95					7			7	3400	131	6	Open-Air		30	41	Local		Fontana + Visentin (2016)
Italy	Casalecchio		Preboreal	E. Meso					1032	14	56	3				9		2		40	1				1			1	1102		6	Open-Air		40	55	Local		Fontana + Visentin (2016)
Italy	Le Mose	Level 3	Preboreal	E. Meso					289	5	29									23	49								372	49		Open-Air		30	44	Local		Fontana + Visentin (2016)
Italy	Le Mose	Level 20	Preboreal	E. Meso					704	8	67	4	2			1		1		9	46			4					779		7	Open-Air		25	44	Local		Fontana + Visentin (2016)
Italy	Collecchio		Preboreal	E. Meso					7356	100	162	11	17			10		11		82	11				20			20	7697	79	7	Open-Air		65	115	Local		Visentin et al. (2014)
Italy	Bagioletto	B22	Preboreal	E. Meso					3411	19	158									93	56								3644	56		Open-Air		31	1725			Fontana + Visentin (2016)
Italy	Mondeval de Sora	Sector I	Preboreal	E. Meso					17648	46	2600	43	11	1	12		26	47		1229	1206	16			9			9	20295		10	Open-Air		24	2130	Non-Local	Good	Fontana et al. (2012)
Italy	Mondeval de Sora	Sector III	Preboreal	E. Meso					3496	20	778									674	710								5004	710		Open-Air		10	2130	Non-Local	Good	Fontana et al. (2012)
Italy	Casera Lissandri	17	Preboreal	E. Meso					10395	49	761	15	3	4				6		348	322		1		46	16		62	11205		8	Open-Air		23	1043	Non-Local		Peresani et al. (2009)
Italy	Cima Dodici	3	Preboreal	E. Meso					6546	18	543	15	13	1			2	3	2	115	356		4		2	2		32	7107		10	Open-Air		25	2050			Angelucci et al. (1999)
Italy	Le Mose	Level 14	Preboreal	E. Meso					300	9	61	3	1			3		1		29	23				1			1	370		7	Open-Air		20	44	Local		Fontana + Visentin (2016)
Italy	Cava Due Portoni		Preboreal	E. Meso					2600	17	86	8	1			2		5		62	3				5			5	3000	297	7	Open-Air	1996	75	1065	Non-Local		Fontana et al. (2009)
Italy	Casera Davià II		Preboreal	E. Sauvet					771	24	205									68									1001			Open-Air		20	1020	Local		Peresani + Bertola (2010)
Italy	Cima Dodici	9	Preboreal	E. Meso						30	221	5	5				5	3		67	120		4			2		12			8	Open-Air		23	2050	Non-Local		Angelucci et al. (1999)
Italy	Frea IV Rockshelter		Preboreal	E. Meso					360	43	322	30								231					36	25		61	725		3	Cave	1994	20	1930	Non-Local		Angelucci et al. (1998)
Italy	Laghetto delle Regole		Preboreal	E. Meso					132		15	3	1					1		6					3	1		4	1147	1039	5	Open-Air	2001	15	1238			Dalmeri et al. (2004)
Italy	Palughetto	US T6	Preboreal	E. Meso			36	44	182	5	24	4								19				1					211		3	Open-Air	2011	91	1800			Peresani et al. (2011)
Italy	Riparo Cogola	US 18	Preboreal	E. Sauvet					6692	7	266	19	5	1				10	168	34				8	11	10		21	14604	7639	8	Open-Air		9	1208			Cusinato et al. (2004)
Italy	Riparo Cogola	US 16	Preboreal	E. Sauvet					2133	9	114	11	4	1		1		8	73	7			1	1	3	4		7	5934	3678	10	Open-Air		9	1208			Cusinato et al. (2004)
Italy	Romagnano III	AF-AE	Preboreal	E. Sauvet							176	4	2	2	1			8	1	143			1		7	7		14			9	Cave	1971	100	220			Boscato et al. (1992)
Italy	Romagnano III	AC 9-7	Preboreal	L. Sauvet							664	79	27	5				18		449		1	6		65	14		79			8	Cave	1971	100	220			Boscato et al. (1992)
Italy	Romagnano III	AC 4-3	Preboreal	L. Sauvet							601	58	25	1				8		435		2	7		51	14		65			8	Cave	1971	100	220			Boscato et al. (1992)
Spain	Atxoste	Vlb2	Preboreal	Epi Mag		165	165	75	240	13	88	7	3	1		3	5	2	51	3									341		8	Cave	1995	18	760	Local	Good	Sebastian (2015)
Spain	Berroberría	Level D Superior	Preboreal	Post-Azilian	8		8	128	136	2	38	6	2			3	3		11	1				11	3			3	176		8	Cave	1977	200	156			Barandier (1979)
Spain	Coma d'Infern		Preboreal	Epi Mag					1036	48	790	66	71	14				44	299	158	153								5528	3577	7	Cave	1964	15	343	Non-Local	Variable	Masferrer (1980)
Spain	Las Forcas	7	Preboreal	Epi Mag						2	9	5	2						1							1		1		1	4	Cave	1990	12	450	Local	High	Utrilla + Mazo (1991)
Spain	Las Forcas	8-9	Preboreal	Epi Mag						5	31	12	5	1		1	2		7							3		3		0	7	Cave	1990	12	450	Local	High	Utrilla + Mazo (1991)
Spain	Picamoixons	CP	Preboreal	Mesolithic				114	114	5	28	8			1		9	1	7			2							153	6	6	Open-Air	1993	4	260			Catalán et al. (2009)
Spain	Urtiaga	C	Preboreal	Epiazilian							292	46	42	4			16	7	161			11		5							8	Cave	1954		1025			Barandiarán + Cava (1989)
Spain	Ekain	Level II	Preboreal	Epiazilian							152	10	3				3	6	114			2		14							7	Cave	1969		89			Barandiarán + Cava (1989)
Spain	Aitzbitarte IV	Ib	Preboreal	Epiazilian							191	52	39	2	4		19	18	45			8		4							9	Cave	1960	6	310			Barandiarán (2014)
Spain	Abauntz	d	Preboreal	Epiazilian			110	205	315	3	80	20	5				9	6	33			2		5							7	Cave	1976	13	706			Mazo + Utrilla (1996)
Spain	Poeymaü	Level 5	Preboreal	Sauveterroide							698	333	91		4		171	84	9			2		4							8	Cave	1948		643			Barandiarán + Cava (1989)
Spain	Poeymaü	Level 4	Preboreal	Sauveterroide							617	362	33		1		140	53	21			1		6							8	Cave	1948		643			Barandiarán + Cava (1989)
Spain	Balma Margineda	c6	Preboreal	Unknown							311	87	16	1	18		58		129	1				1							8	Cave		135	970			Martínez-Moreno et al. (2006)
Spain	Kanpanoste Goikoa	Level III-Lower	Preboreal	Unknown				83	83	12	38	9		2			19							7	1			1	556	403	5	Cave	1992		740	local	Variable	Ruiz (1997)
Spain	Filador	7	Preboreal	Unknown						86	886	87	10				15		212	97	257			223					16768		7	Cave	1973	27	350			Andreu et al. (2005)
Spain	Filador	5-6	Preboreal	Unknown						0	39	5	1				1		6	9	17								469		6	Cave	1973	10	350			Andreu et al. (2005)
Spain	Filador	4	Preboreal	Unknown						37	388	13	19				9	13	94	32	168								6067		7	Cave	1973	26	350			Andreu et al. (2005)

Southern European Transitional Assemblage Data

Allerod/YD

Country	Site Name	Assemblage	Climate	Culture	B	B'lets	B+B'lets	F	Bl	C	T	ES	Bu	Bo	SP	No	Den	Trunc	P	MBu	MF	Other	RF	RB	RB'lets	TR	TL	Waste	NTAXA	Site Type	Ex Year	Area (m2)	Altitude	RMS	RMQ	Source
Spain	Balma Guilanyà	Level E	A/YD	Unknown							156	27	1	0	4	7	11	2	13			57		34		34			9			9	1160			Martínez-Moreno (2009)
France	Fru à Saint-Christophe-la-Grotte	Layer 2	A/YD	Azilian							148	56	8	2				9	53			0	10	3	7	20			6	Cave	1980	9	570	Local	Variable	Pion (1997)
France	Fru à Saint-Christophe-la-Grotte	Layer 5	A/YD	Azilian							76	23	3					2	33			0	15			15			5	Cave	1980		570	Local	Variable	Pion (1997)
France	Merveilles II		A/YD	Azilian					235	3	39	11		6				2	20			0					500	225	4	Open Air	1991	200	116			Bazile + Monnet-Bazile (1998)
France	Vignes		A/YD	Azilian	1		1	14	15	2	62		2						27			3			30	30	142	63	4				230			Lelouvier et al. (2012)
Italy	Malga Campoluzzo di Mezzo		A/YD	F. Epigrav			72	69	141	3	56	10	4	1		1	2	3	22	9	1	0		3		3	191		10	Rockshelter			1401			Angelucci (200)
Spain	Molí del Salt		A/YD	FUP							1371	529	48	34			172	81	266			70				171			8	Rockshelter	1999		490			Vaquero et al. (2012)

YD/PB

Country	Site Name	Assemblage	Climate	Culture	B	B'lets	B+B'lets	F	Bl	C	T	ES	Bu	Bo	SP	No	Den	Trunc	P	ML	MBu	MF	Other	RF	RB	RB'lets	TR	TL	Waste	NTAXA	Site Type	Ex Year	Area (m2)	Altitude	RMS	RMQ	Source
Spain	Atxoste	Vlb	YD/PB	Sauveterroide		744	744	577	1321	65	262	35	11		35	16	13	11	116	25								1684	36	8	Rockshelter	1995	18	760	Local	Good	Sebastian (2015)
Spain	Cativera	B	YD/PB	Unknown	557	117	674	385	1059	17	153	81	7	3			19	7	33				3					1442	212	7	Rockshelter	2002	20	65	Local	Poor	Hidalgo (2010)
Spain	Cativera	Bb	YD/PB	Unknown	293	81	374	295	669	8	49	28	3	1			5	3	7				2					964	238	7	Rockshelter	2002	20	65	Local	Poor	Hidalgo (2010)

Data References

Alday, A., Soto, A., de Heredia, J.L., Perales, U., (2012), El abrigo de Martinarri (Obécuri, Treviño): Una ocupación del Tardiglaciar en la Cuenca Alta del Ebro, Trabajos de prehistoria, Vol. 69:2, pp. 257-272.

Allard, M., (2013), Un campement épipaléolithique de chasseurs dans l'ouest de la France Le site 1 du Camp d'Auvours à Saint-Mars-la-Brière (Sarthe, France), Paleo, Vol. 24, pp. 2-37.

Allen, T. G., Barton, N., Brown, A., (1995), Lithics and landscape: archaeological discoveries on the Thames Water pipeline at Gatehampton Farm, Goring, Oxfordshire 1985-92, Oxford Archaeological Unit.

Ameels, V., Van Vlaenderen, L., (1995), Epipaleolithische en Vroeg-Mesolithische sites Langsheen, de Moervaart (oost-Vlaanderen), Notae Prehistoricae, Vol. 15, pp. 35-43.

Andreu, P. G. A., Lorenzo, J. N. I., Pericot, J. M. F. I., (2005), El abrigo del Filador (Margalef de Montsant, Tarragona) y su contextualización cultural y cronológica en el nordeste peninsular, Trabajos de Prehistoria, Vol. 62:1, pp. 65-83.

Angelucci, D. E., (2000), Un nuovo sito paleolitico nelle Prealpi Venete: Malga Campoluzzo di Mezzo (Vicenza), Preistoria Alpina, Vol. 31, pp. 37-51.

Angelucci, D. E., Alessio, G., Bartolomei, G., Cassoli, P. F., Importa, S., Maspero, A., Tagliacozzo, A., (1998), The Frea IV rockshelter (Selva V al Gardena, BZ), Preistoria Alpina, Vol. 34, pp. 99-109.

Angelucci, D. E., Frigo, G., Martello, G. V., Peresani, M., (1999), Les sites d'altitude à Cima Dodici (plateau d'Asiago, Italie): Nouvelles données sur les peuplements de l'Holocène récent des Préalpes du Sud, L'Europe des derniers chasseurs, Actes du 5e Colloque International UISPP, Commission XII (Grenoble, 18-23 septembre 1995), pp. 449-455.

Argilagós, J. B., Lorenzo, J. N., Monroig, D. R., Martín, A. E., (2015), Antiguas excavaciones, nuevas respuestas: El yacimiento epimagdaleniense de la Cova del Clot de l'Hospital (Roquetes, Baix Ebre), SAGVNTVM (P.L.A.V.), Vol. 47, pp. 9-27.

Arts, N., (2012), Milheeze – A very large Federmesser site on the northern edge of the Peel peat bog (Southern Netherlands) and its environmental and social context, in: Niekus, M. J. L., Th., Barton, R. N. E., Street, M., Terberger, Th., (Eds.), A mind set on flint Studies in honour of Dick Stapert, Groningen Archaeological Studies 16, pp. 267-279.

Arts, N., Deeben, J., (1977), Mogelijke sporen van de Ahrensburgkultuur langs de Nieuwe Aa in de gemeente Someren, Brabants heem, Vol. 29:3, pp. 101-104.

Arts, N., Deeben, J., (1978), Een Federmesser nederzetting te Oostelbeers: Een rapport betreffende de noodopgraving in 1976, Brabants Heem, Vol. 30, pp. 60-75.

Audouze, F., Cahen, D., Keeley, L. H., (1981), Béatrice SchmiderLe site magdalénien du Buisson Campin à Verberie (Oise), Gallia préhistoire, Vol. 24:1, pp. 99-143.

Avanzini, M., Broglio, A., De Stefani, M,., Lanzinger, M., Lemorini, C., Rossetti, P., (1997), The Tschonstoan Rock Shelter at Alpe di Siusi-Seiser Aim, Preistoria Alpina, Vol. 34, pp. 81-98.

Baales, M. (2002), Der spätpaläolithische Fundplatz Kettig. Untersuchungen zur Siedlungsarchäologie der Federmesser-Gruppen am Mittelrhein. Monographien des Römisch-Germanischen Zentralmuseums 51. Mainz & Bonn.

Baales, M., Mewis, S. U., Street, M., (1998), Der Federmesser-Fundplatz Urbar bei Koblenz. Jahrbuch des Römisch-Germanischen Zentralmuseums Mainz 43, pp. 241-279.

Barandiar, I., (1979), Excavaciones en el covacho de Berroberria (Urdax), campaña de 1977, Trabajos de Arqueología Navarra, Vol. 1, pp. 11-60.

Barandiarán, I., Cava, A., (1986), Yacimiento de Portugain (Urbasa, Navarra). Informe preliminar de las campañas de excavación de 1984 y 1985. Trabajos de Arqueología Navarra, 5, pp.7-18.

Barandiarán, I., Cava, A., (1989), El yacimiento arqueológico de Zatoya y las condiciones de su ocupación desde fines del Tardiglaciar a mediados del Holoceno, in: Cava, A., (Eds.), El yacimiento prehistorico de Zatoya (Navarra): Evolución ambiental y cultural a fines del Tardiglaciar y en la primera mitad del Holoceno, pp. 291-351.

Barandiarán, I., Cava, A., (2001), El Paleolítico superior de la cueva de Zatoya (Navarra): actualización de los datos en 1997, Trabajos de Arqueología Navarra, Vol. 15, pp. 5-99.

Barandiarán, J.M.D., (2014), Excavaciones en Aitzbitarte IV: (campaña de 1964), Autorizadas por Orden del 10-III-1964.

Barton, R. N. E., (1992), Hengistbury Head, Dorset Volume 2: The Late Upper Palaeolithic and Early Mesolithic sites, Oxford University Committee for Archaeology, Monograph No. 34.

Barton, R. N. E., Ford, S., Collcutt, S., Crowther, J., Macphail, R., Rhodes, E., Van Gijn, A., (2009), A Final Upper Palaeolithic site at Nea Farm, Somerley, Hampshire (England) and some reflections on the occupation of Britain in the Late Glacial Interstadial, Quartär, Vol. 56, pp. 7-35.

Battaglia, L., Lanzinger, M., (1994), Abri Soman, Unknown Publisher.

Bazile, F., Monnet-Bazile, C., (1998), Le gisement épipaléolithique de la Grange des Merveilles II, Rochefort-du-Gard, Gard: Note préliminaire, Bulletin de la Société Préhistorique Française, Vol. 95:4, pp. 467-474.

Beugnier, V., Crombé, P., (2005), Étude fonctionnelle du matériel en silex du site mésolithique ancien de Verrebroek (Flandres, Belgique): premiers résultats, Bulletin de la Société Préhistorique Française, Vol. 102:3, pp. 527-538.

Beuker, J. R., Niekus, M. J. L. T., (2003), Het gebruik van rode Helgoland-vuursteen in het laat-paleolithicum, Nieuwe Drentse Volksalmanak. p. 112 - 120.

Biard, M., Prost, D., (2015), Le debitage a la pierre tendre: Example de deux postes de taille de l'extreme fin du Paleolithique en Haute-Normandie, Bulletin de la Societe Prehistorique Francais, Vol. 112:1, pp. 59-73.

Bjerck, H. B., Breivik, H. M., Fretheim, S. E., Zangrando, A. F. J., (2012), Report, Excavation of Mohalsen2012-II (Vega Island, Norway), Technical Report, December 2012.

Blank, R., (1985), Ein Fundplatz der endpalaolithschen steilspltzen-gruppe am Nordlichen Mittlgebirgsrand, Archäologisches Korrespondenzblatt, Vol. 3:3, pp. 287-292.

Bogen, C., Hilgers, A., Kaiser, K., Kuhn, P., Lidke, G., (2003), Archäologie. Pedologie und geochronologie Spätpälaolithischer fundplätze in der Ueckermunder Heide (Mecklenburg-Vorpommern), Archäologisches Korrespondenzblatt, Vol. 33, pp. 1-20.

Bolivar, S. V., Martínez-Moreno, J., Mora, R., (2012), Nous elements de discussió entorn de l'espai magdalenià dels Prepirineus orientals: La Cova Gran de Santa Linya (les Avellanes, la Noguera), 3r col·loqui d'Arqueologia d'Odèn cronológico-cultural, Antropologia-Arkeologia, No. 49, pp. 3-50.

Bonsall, C. J., (1977), Gazetteer of Upper Palaeolithic sites in England and Wales, CBA Research Report, No. 20, pp. 417-511.

Bordes, F., Fitte, B., (1951), Une industrie épipaléolithique à Evreux. In: Bulletin de la Société préhistorique de France, Vol. 48:3-4, pp. 147-154.

Bordes, F., Graindor, M. J., Martin, P. R., Martin, Y., (1974), L'industrie de la grotte ornée de Gouy (Seine-Maritime), Bulletin de la Société préhistorique française, Comptes rendus des séances mensuelles, Vol. 71:4, pp. 115-118.

Boscato, P., Broglio, A., Cattani, L., Perini, R., Sala, B., (1992), Romagnano III: Excursions dans les sites paléolithiques et mésolithiques du Bassin de l'Adige, des Dolomites et du Haut-Plateau d'Asiago, Preistoria Alpina - Museo Tridentino di Scienze Naturali, Vol. 28, pp. 269-264.

Bosquet, D., Jadin, I., De Ruijter, A., Clarys, B., (1994), Sauvetage d'un site mésolithique ancien à Rebecq, lieu-dit Le Spinoi (Brabant wallon), Notae praehistoricae, Vol. 14, pp. 85-90.

Bosselin, B., (1982), L'habitat epimagdalenien des Bruyeres: Essai d'analyse et d'interpretation des structures, Bulletin de la Societe Prehistorique Francaise, Vol. 79:5, pp. 138-147.

Bracco, J. P., Gagnepain, J., Stouvenot, C., Bidart, P., Vigier, S., (1997), L'industrie lithique épigravettienne de Saint-Antoine - Locus 2 (Vitrolles, Hautes-Alpes): Première analyse, Paléo, No. 9, pp. 221-243.

Breest, K., Graff, K. H., (2007), Mittel- und spätpaläolithische Funde von Handeloh, Gde. Höckel, Kdkr. Harburg, Nachrichten aus Niedersachsens Urgeschichte, Vol. 76, pp. 3-27.

Broglio, A., (1994), Le site épigravettien de Val Lastari sur l'Haut Plateau d'Asiago (Préalpes de la Vénétie), Museo Tridentino di Scienze Naturali, Vol. 28, pp. 207-225.

Brou, L., (1998), Découverte d'une occupation Epipaléolithique ou Mésolithique ancien à Remerschen-Enner dem Raederbierg (Grand-Duché de Luxembourg), Présentation et implications, Bull. Soc. Prehist. Luxembourgcoise, Vol. 20, pp. 197-223.

Buckland, P. C., (1976), Archaeology and environment in the Vale of York: Studies in the use of insect remains in the interpretation of archaeological environments, PhD thesis, University of Birmingham.

Catalán, S. G., Rodríguez, M. V., Goñi, I. P., Iglesias, B. M., García, L. P., López, R.B., Flores, E.M., García, D.M., Encinar, L.M., (2009), Palimpsestos y cambios culturales en el límite Pleistoceno-Holoceno: el conjunto lítico de Picamoixons (Alt Camp, Tarragona), Trabajos de Prehistoria, Vol. 66:2, pp. 61-76.

Catalán, S.G, Rodríguez, M.V., (2015), La variabilidad tecnológica del Paleolítico superior final en el sur de Cataluña: La cueva de la Mallada (Perelló, Tarragona) y el abrigo de l'Areny (Vilanova d'Escornalbou, Tarragona), Trabajos de Prehistoria, Vol. 72:1, pp. 64-83.

Clark, J. G. D., (1971), Excavations at Star Carr: An Early Mesolithic site at Seamer near Scarborough, Yorkshire, Cambridge University Press.

Cliquet, D., Lautridou, J. P., (1994), Le gisement Paleolithique Superieur des Bas-Fayaux a Everux (Eure), in Fagnart, J. P., Thevenin, A., (Eds), Le Tardiglaciare en Europe du Nord-West, Actes du 119e Congres National des Societes Historiques et Scientifiques, pp. 257-263.

Conneller, C., Ballantyne, R., French, C., Speller, G., (2009), Investigation of a Final Palaeolithic site at Rookery Farm, Great Wilbraham, Cambridgeshire, Proceedings of the Prehistoric Society, Vol. 75, pp. 167-187.

Conneller, C., Elis, C., Allen, M. J., Macphail, R., Scaife, R., (2007), A Final Upper Palaeolithic site at La Sagesse Convent, Romsey, Hampshire, Proceedings of the Prehistoric Society, Vol. 73, pp. 191-227.

Cooper, L. P., (2006), Launde a Terminal Palaeolithic camp-site in the English Midlands and its north European Context, Proceedings of the Prehistoric Society, Vol. 72, pp.53-94.

Coudret, P., Fagnart, J. P., (2004), Les fouilles du gisement Paleolithique Final de Saleux (Somme), RAP, No. 1/2, pp. 3-17.

Coudret, P., Limondin, N., Munaut, A. V., (1995), Le gisement paléolithique final des Prés du Mesnil à La Chaussée-Tirancourt (Somme), Bulletin de la Société préhistorique française, Vol. 92:2, pp. 227-234.

Crombé, P., (1998), The Mesolithic in northwestern Belgium: Recent excavations and surveys, BAR International Series 716.

Crombé, P., Beugneir, V., (2013), La fonction des industries en silex et les modalités d'occupation des territoires au Mésolithique. Le cas des zones sableuses du nord-ouest de la Belgique et des Pays-Bas (8700–5400 cal. BC), L'Anthropologie, Vol. 117:2, pp. 172-194

Crombé, P., Deforce, K., Langohr, R., Louwagie, G., Perdaen, Y., Sergant, J., Verbruggen, C., (1999), A small Final-Palaeolithic knapping site at Verrebroek "Dok 2" (Flanders, Belgium), Notae Praehistoricae, Vol. 19, pp. 63-68.

Crombé, P., Sergant, J., Verbrugge, A., De Graeve, A., Cherette, B., Mikkelsen, J., Cnudde, V., De Kock, T., Huisman, H. D. J., Van Os, B. J. H., Van Strydonck, M., Boudin, M., (2014), A sealed flint knapping site from the Younger Dryas in the Scheldt valley (Belgium): Bridging the gap in human occupation at the PleistoceneeHolocene transition in W. Europe, Journal of Archaeological Science, Vol. 50, pp. 420-439.

Cusinato, A., Dalmeri, G., Kompatscher, K. Kompatscher, M. H., (2004), Gli insiemi litici della sequenza preistorica di Riparo Cogola e la problematica relativa alla transizione tra Epigravettiano e Mesolitico in area alpina, Preistoria Alpina, Vol. 40, pp. 125-154.

Dalmeri, G., Duches, R., Avanzini, M., Bassetti, M., Flor, E., Neri, S., (2013), Frequentazione delle medie quote montane durante il Dryas recente: Nuove informazioni dal sito epigravettiano di Palù Echen (Altopiano di Folgaria, Trentino), Preistoria Alpina, Vol. 47, pp. 153-181.

Dalmeri, G., Kompatscher, K., Kompatscher, M. H., Bassetti, M., Custinato, A., Piazzi, O., (2004), Dinamiche comportamentali degli ultimi cacciatori raccoglitori in area alpina. Il caso di studio del sito LR3 del Laghetto delle Regole (Castelfondo, Trento), Preistoria Alpina, Vol. 40, pp. 5-27.

De Bie, M., Casper, J. P., (2000), Rekem: A Federmesser Camp on the Meuse River Bank (Acta Archaeologica Lovaniensia Monographiae, 10), Leuven University.

De Wilde, D., Verbreek, C., De Bie, M., (2007), De lithische technologie van Weelde-Eindegoorheide 12 en 13 (prov. Antwerpen), Notae Prehistoricae, Vol. 27, pp. 61-64.

De Wilde, D., Verbreek, C., De Bie, M., (2007), De lithische technologie van Weelde-Eindegoorheide 12 en 13 (prov. Antwerpen), Notae Prehistoricae, Vol. 27, pp. 61-64.

Deeben, J., (2012), Laat-paleolithische bewoning langs de Maasmeander van het Koelbroek. Westerheem. 61. 70-75.

Deeben, J., Brinkkemper, O., Groenewoudt, B., Lauwerier, R., (2006), Een Federmesser-site van de Enterse Akkers, (gemeente Wierden, Overijssel), in: Groenewoudt, B. J., Van Heeringen, R. M., Scheepstra, G. H., (Eds.), Het zandeilandenrijk van Overijssel, Nederlandse Archeologische Rapporten 22, Rijksdienst voor het Oudheidkundig Bodemonderzoek, Amersfoort, pp. 49-82.

Deeben, J., Schreurs, J., (2012), The Pope, a miracle and an Ahrensburgian windbreak in the municipality of Waalre (province of Noord-Brabant), the Netherlands, in: Niekus, M. J. L., Th., Barton, R. N. E., Street, M., Terberger, Th., (Eds.), A mind set on flint Studies in honour of Dick Stapert, Groningen Archaeological Studies 16, pp. 295-319.

Demolon, P., Tuffreau, A., (1972), Présentation du Paléolithique supérieur des Plats Monts à Ecourt-Saint-Quentin (Pas-de-Calais), Bulletin de la Société préhistorique française. Études et travaux, Vol. 69:1, pp. 356-363.

Dewez, M., (1987), Le paléolithique supérieur récent dans les grottes de Belgique, Louvain-la-Neuve, Belgique, Institut supérieur d'archéologie et d'histoire de l'art, Collège Erasme.

Dijkstra, P., Bink, M., De Bie, M., Vynckier, G., Van Rechem, H., Dyselinck, T., (2006), Laatpaleolithische vindplaatsen op het Plinius-terrein bij Tongeren (prov. Limburg), Notae Praehistoricae, Vol. 26, pp. 109-124.

Dini, M., Sagramoni, A., (2005), Analisi dei prodotti della scheggiatura del sito dell’Epigravettiano finale di La Greppia II–US 1 (Parco Naturale dell’Orecchiella–Lucca), Preistoria Alpina, Vol. 41, pp. 5-21.

Drenth, E., (2015), (Un)burnt flint artefacts as indicators of Late Palaeolithic and Mesolithic anticipation and Curation? An exploratory study for the southern Netherlands, Notae Praehistoticae, Vol. 35, pp. 305-311.

Duches, R., Peresani, M., Ziggiotti, S., (2007), Nuovi dati sul popolamento antropico delle Prealpi Carniche nel tardoglaciale: Il sito di Pian delle More sul Piancavallo, Rivista di Scienze Preistoriche, Vol. 57, pp. 93-102.

Ellis, C. J., Allen, M. J., Gardiner, J., Harding, P., Ingrem, C., Powell, A., Scaife, G., Gale, R., Heathcote, J., (2003), An Early Mesolithic seasonal hunting site in the Kennet valley, southern England, Proceedings of the Prehistoric Society, Vol. 69, pp. 107-135.

Fagnard, J. P., Roussel, M. C., Roussel, J. P., (1981), Le gisement mésolithique de la Haute Borne à Beaulieu-les-Fontaines (oise), Revue archéologique de l'Oise. N0. 24, pp. 2-9.

Fagnart, J. P., (1979), Le site épipaléolithique des basses pâtures à Maroilles (Nord): Etude préliminaire, Revue de Nord, Vol. 61:243, pp. 755-764.

Fagnart, J. P., (1982), Le gisement paléolithique final du hameau d'Etouvie à Amiens, Revue archéologique de Picardie. No. 4, pp. 36-48.

Fagnart, J. P., (1988), Le Bois Défriché à Villers-Tournelle (Somme), Revue archéologique de Picardie, Numéro spécial 7, pp. 116-117.

Fagnart, J. P., (1988), Le Bois d'Holnon à Attilly (Aisne), Revue archéologique de Picardie. Numéro spécial 7, Les industries lithiques du Paléolithique supérieur dans le Nord de la France. pp. 73-79. AND Fagnart, J. P., (1988), Inventaires typologiques, Revue archéologique de Picardie. Numéro spécial 7, Les industries lithiques du Paléolithique supérieur dans le Nord de la France. pp. 139-140.

Fagnart, J. P., (1988), Le gisement de Dreuil-lès-Amiens (Somme), Revue archéologique de Picardie. Numéro spécial 7, Les industries lithiques du Paléolithique supérieur dans le Nord de la France, pp. 59-69.

Fagnart, J. P., (1988), Le gisement de Hamel (Nord), Revue archéologique de Picardie. Numéro spécial 7, Les industries lithiques du Paléolithique supérieur dans le Nord de la France, pp.. 84.

Fagnart, J. P., (1988), Le gisement du Bois du Brûle à Ercheu (Somme), Revue archéologique de Picardie. Numéro spécial 7, pp. 86-88.

Fagnart, J. P., (1988), Les Plats Monts à Ecourt-Saint-Quentin (Pas-de-Calais), Revue archéologique de Picardie. Numéro spécial 7, Les industries lithiques du Paléolithique supérieur dans le Nord de la France, pp. 82-83.

Fagnart, J. P., (1992), Nouvelles observations sur le gisement paléolithique supérieur de Belloy-sur-Somme (Somme), Gallia préhistoire, Vol.34, pp. 57-83.

Fagnart, J. P., Limondin, N., Munaut, A. V., (1995), Le gisement paléolithique supérieur final du marais de Flixecourt (Somme), Bulletin de la Société Préhistorique Française. 1995, Vol. 92:2, pp. 235-248.

Fischer, A., (1990), A late Palaeolithic flint workshop at Egtved, East Jutland, Journal of Danish Archaeology, Vol. 7, pp. 7-23.

Fischer, A., (2012), The Fensmark settlement and the almost invisible Late Palaeolithic in Danish field archaeology, Danish Journal of Archaeology, Vol. 1:2, 123-141.

Floss, H., (1989), Der Ziegenberg bei Althenrath: Ein Fundplatz der Ahrensburger Stielspitzengruppen am sudostrand der Kolner Bucht, Jarbuch des Römisch-Germanischen Zentralmuseums Mainz (1987), Vol. 34, pp. 169-196.

Fontana, F., Cremona, M. G., Cavallari, P., Gazzoni, V., Palavanchi, S., (2009), Variability of lithic technical systems in the Sauveterrian of the Southern Po Plain area (Northern Italy), Human evolution, Vol. 24:2, pp. 153-164.

Fontana, F., Hohenstein, U. T., Bertola, S., Guerreschi, A., Petrucci, G., Ziggiotti, S., Rinaldi, G., Turrini, M. C., Valletta, F., (2012). The Early Mesolithic Occupation of Mondeval De Sora (Belluno, Dolomites): A residual site or a hunting camp?, Journal of Biological Research-Bollettino della Società Italiana di Biologia Sperimentale, Vol. 85:1, pp. 80-84.

Fontana, F., Visentin, D., (2016), Between the Venetian Alps and the Emilian Apennines (Northern Italy): Highland vs. lowland occupation in the early Mesolithic. Quaternary International, Vol. 423, pp. 266-278.

Ford, S., (1995), The Excavation of a Saxon Settlement and a Mesolithic Flint Scatter at Northampton Road, Brixworth, Northamptonshire, Northamptonshire Archaeology, Vol. 26, pp. 79-108.

Fosse, G., (1993), Le Gisement du Paléolithique supérieur final de Blaru (Yvelines), Paléo, Vol. 5, pp. 249-261.

Fosse, G., (1994), Le Paleolithique recent et final du bassin de la Basse-Seine, in Fagnart, J. P., Thevenin, A., (Eds), Le Tardiglaciare en Europe du Nord-West, Actes du 119th Congres National des Societes Historiques et Scientifiques, pp. 233-244.

Froom, R., (2005), Late Glacial Long Bad sites in the Kennet Valley: Excavations and fieldwork at Avington VI, Wawcott XII and Crown Acres, The British Museum Research Publication Number 153, The British Museum.

Garcia-Argüelles, P., Estrada, A., Nadal, J., Fullola, J.M., Mangado, X., (2009), Les niveaux épipaléolithiques de la Balma del Gai (Moià, Barcelone, Catalogne): De Méditerranée et d'ailleurs, Mélanges offerts à Jean Guilaine, pp. 299-310.

Gardiner, J., Allen, M. J., Lewis, J. S. C., Wright, J., Macphail, R. I., James, S. E., (2007), A Long Blade site at Underdown Lane, Herne Bay, Kent, and a Model for Habitat Use in the British Early Postglacial, Wessex Archaeology, Report.

Gelhausen, F., (2009), Die Fundkonzentrationen der Fläche II des allerødzeitlichen Fundplatzes Niederbieber, Stadt Neuwied (Rheinland-Pfalz), Jahrbuch des Römisch-Germanischen Zentralmuseums Mainz 56:1, pp. 1-38.

Ghesquière, E., Auguste, P., Piel-Desruisseaux, J. L., (2012), Le site mésolithique de Fumichon, Vallée de la Pâquine, (Calvados), Revue archéologique de l'Ouest, Vol. 29, pp. 2-21.

González, J. E., Ibáñez, J. J., (1991), La tecnología de talla laminar en la ocupación epipaleolítica de Berniollo (Subijana-Morillas, Alava), Treballs d'Arqueologia, Vol. 1, pp. 201-222.

Gouletquer, P., Leopold, P., (1991), Etat provisoire d'une prospection de longue durée: le site mésolithique de Quillien (Le Cloître St-Thégonnec, Finistère), Revue archéologique de l'ouest, Vol. 8, pp. 61-82.

Gramsch, B., Kloss, K., (1990), Excavations near Friesack: An Early Mesolithic marshland site in the northern plain of Central Europe, in: Bonsall, C., (Eds.), The Mesolithic in Europe, Papers presented at the third International Symposium, Edinburgh, 1985, John Donald Publishers ltd., pp. 313-324.

Griffin, A. M., (2015), A Late Magdalenian Landscape: Spatial and Technological Production at Les Eglises, PhD Thesis, Berkeley University.

Groenewoudt, B. J., Beeben, J., Van Geel, B., Lauwerier, R. C. G. M., (2001), An Early Meoslithic assemblage with faunal remains in a stream valley near Zutphen, The Netherlands, Archäologische Korrespondenzblatt, Vol. 31:3, pp. 329-348.

Hansen, K. M., Pedersen, K. B., (2006), With or without bones – Late Palaeolithic hunters in South Zealand, in Hansen, K. M., Pedersen, K. B., (Eds.), (2006), Across the western Baltic: Proceedings from an archaeological conference in Vordingborg, pp. 93-110.

Hantaï, A., (1997), Le " Belloisien " jusque sur les bords de la Loire: Les gisements du Paléolithique final de Muides-sur-Loire (Loir-et-Cher), Revue archéologique du Centre de la France, Vol. 36, pp. 5-22.

Heidenreich, S. M., (2009), Zur räumlichen Analyse paläolithischer Fundstellen - das Beispiel des spätpaläolithischen Fundplatzes von Salzkotten-Thüle, Kr. Paderborn, Archäologische Korrespondenzblatt, Vol. 39:2, pp. 163-182.

Heinen, M., Joris, O., Riedmeier-Fischer, E., Thissen, J., (1996), Ein Federmesserfundplatz im Tal der Niers bei Goch, Kr. Kleve: Rekonstruktion eines kurzzeitigen Jagdaufenthaltes, Archäologisches Korrespondenzblatt Vol. 26, pp. 111-120.

Hemmann, L., Pasda, C., Vokler, D., (2008), Ölknitz, Jena, Rothenstein – Drei Fundstellen des Magdaléniens im Saale-Tal in Thüringen, Archäologische Korrespondenzblatt, Vol. 38:1, pp. 1-12.

Herne Bay, Kent, and a model for habitat use in the British Early Postglacial, Wessex Archaeology Report, Ken Archaeological Society."

Hidalgo, J. I. M., (2010), La Cativera (Tarragona): La tecnología lítica de los últimos cazadores-recolectores en el Noreste de la Península Ibérica, Masters Thesis, Universitat Rovira i Virgili.

Hinout, J., (1985), Le gisement epipaleolithique de la Muette I commune du Vieux-Moulin (Oise), Bulletin de la Société Préhistorique Française, Vol. 82:10-12, pp. 377-388.

Hinout, J., (1988), Gisements Epipaleolithiques dans la Bassin Parisen: Notes peliminares, in: Otte, M., (Eds.), De la Loire a l'Order: Les civilisations du Paleolithique Final dans le nord-ouest Europeen, Acts du Colloque de Leige, Decembre, 1985, Etudes et Reserches Archeologiques de l'Universie de Leige, No. 25, Vol. 1, BAR International Series 444(i), pp. 163-181.

Hinout, J., (1992), Le gisement épipaléolithique de Hannappes (Aisne), Revue archéologique de Picardie, No. 1-2, pp. 3-9.

Holm, J., (1991), Settlements of the Hamburgian and Federmesser Cultures at Slotseng, South Jutland, Journal of Danish Archaeology, Vol. 10, pp. 7-19.

Houtsma, P., Kramer, E., Newell, R. R., Smit, J. L., (1996), The Late Palaeolithic habitation of Haule V: From excavation report to the reconstruction of Federmesser settlement patterns and land-use, Van Gorcum Publications.

Houtsma, P., Roodenberg, J. J., Schilstra, J., (1981), A site of the Tjonger tradition along the Schipsloot at Een (gemeente of Norg, province of Drenthe, the Netherlands), Palaeohistoria, Vol. 23, pp. 73-102.

Huet, F., (1995), Le gisement Mésolithique ancien de Verseilles-le-Bas, canton de Longeau (Haute-Marne): Epipaléolithique et Mésolithique entre Seine et Marne, Annale littéraires de l'Uni-versité de Besançon, Vol. 567, pp. 125-144.

Huyge, D., (1985), An Early Mesolithic site at Zonhoven-Kapelberg (Belgian Limburg), Notae praehistoricae, Vol. 5, pp. 37-42.

Huyge, D., Vermeesch, P. M., (1982), Mesolithique Ancien a Schulen, in: Vermeersch, P. M., (Eds.), Contributions to the study of the Mesolithic of the Belgian Lowland, Studia Praehistorica Belgica, Vol. 1, pp. 56-112.

Jacquier, J., (2014), Analyse fonctionnelle des outillages lithiques et interprétations socio-économique du statut des sites tardiglaciaires du Buhot à Calleville (Eure) et de la Fosse à Villiers-Charlemagne (Mayenne), in: Langlais, M, Naudinot, N., Peresani, M., (Eds.), Les groupes culturels de la transition Pléistocène-Holocène entre Atlantique et Adriatique Actes de la séance de la Société préhistorique française de Bordeaux, 24-25 mai 2012, pp. 221-246.

Janković, I., Ahern, J. C., Karavanić, I., Stockton, T., Smith, F. H., (2012), Epigravettian human remains and artifacts from Šandalja II, Istria, Croatia, PaleoAnthropology, 2012, pp. 87-122.

Jochim, M. A., (1995), Two Late Paleolithic Sites on the Federsee, Germany. Journal of Field Archaeology, Vol. 22:3, pp. 263-273.

Johansson, A. D., (1990), Barmosegruppen: Praeboreale bopladsfund I sydsjaelland, Aarhus University.

Jones, P., (2013), Upper Palaeolithic sites in the lower courses of the rivers Colne and Wey: Excavations at Church Lammas abd Wey Manor Farm, Monography 5, SpoilHeap Publications

Kaiser, K., Clausen, I., (2005), Palaeopedology and stratigraphy of the Late Palaeolithic Alt Duvenstedt site, Schleswig-Holstein (northwest Germany), Archäologisches Korrespondenzblatt, Vol. 35, pp. 447-466.

Kayser, O., Le Goff, J. C., D., Roue D., (1990), Le site mésolithique de Toul-an-Naouc'h (Plougoulm, Finistère). Revue archéologique de l'ouest, Vol. 7, pp. 23-29.

Kindgren, H., (2002), Tosskarr. Stenkyrka 94 revisited, in: Bratlund B., Eriksen, B. V., (Eds.), Recent studies in the Final Paleolithic of the European Plain, pp. 49-60.

Komso, D., Pellegatti, P., (2007), The Late Epigravettian in Istra: Late Paleolithic colonization and lithic technology in the northern Adriatic Area, in: Whallon, R., (Eds.), Late Paleolithic environments and cultural relations around the Adriatic, BAR International Series 1716, pp. 27-39.

Kotthaus, J. K., (2013), The late glacial Federmesser site of Borneck-Ost, Germany: A technological re-analysis of the lithic assemblage using a chaîne opératoire approach, Masters Thesis, University of Oslo

Koxvold, L. U., (2011), Puzzling Sujala: A refitting study of the lithic material from a post-Swiderian site in the interior of northern Finnish Lapland, Masters Thesis, University of Oslo.

Lauwers, R., (1982), Un site Mesolithique a Neerharen-De Kip, in: Vermeersch, P. M., (Eds.), Contributions to the study of the Mesolithic of the Belgian Lowland, Studia Praehistorica Belgica, Vol. 1, pp. 18-48

Lefevre, P., (1994), Approche technologique du debitage et economie de la matiere premiere de l'industrie lithique du site de Flamanville (Manche), in Fagnart, J. P., Thevenin, A., (Eds), (1994), Le Tardiglaciare en Europe du Nord-West, Actes du 119e Congres National des Societes Historiques et Scientifiques, pp. 279-292

Lelouvier, L. A., Bosc-Zanardo, B., Bruxelles, L., Chalard, P., Jary, M., (2012), En Vignes, une halte de chasse tardiglaciaire à Marsan dans le Gers (France), Bulletin de la Société Préhistorique Française, Vol. 109:1, pp. 105-119.

Leroi-Gourhan, A., Brezillon, M., (1966), L'habitation magdalénienne n° 1 de Pincevent près Monterau (Seine-et-Marne), Gallia préhistoire, Vol. 9:2, pp. 263-385.

Leroy, G., (2013), Une occupation de l'extrême fin du Paléolithique dans la vallée de l'Escaut à Proville (Nord): Le Bois Chenu, Bulletin de la Société Préhistorique Française, Vol. 110:4, pp. 691-702.

Lewis, J. S. C., Rackham, J., (2011), Three Ways Wharf, Uxbridge: A Lateglacial and Early Holocene hunter-gatherer site in the Colne Valley, Monograph 1, Museum of London Archaeology, Lavenham Press.

Loew, A. S., (2005), Der Federmesser-Fundplatz Rüsselsheim 122 am Unteren Main (Hessen), Archäologische Korrespondenzblatt, Vol. 35:2, pp. 143-158.

Madsen, B., (1983), New evidence of Late Palaeolithic settlement in East Jutland, Journal of Danish Archaeology, Vol. 2, pp. 12-31.

Marchand, G., Monnier, J. L., Pustoc'h, F., Quesnel, L., (2014), Un visage original du Tardiglaciaire en Bretagne: les occupations aziliennes dans l’abri-sous-roche de Kerbizien à Huelgoat », PALEO, Vol. 25, pp. 125-168.

Marchand, G., Sicard, S., Forre, P., Nauleau, J. F., (2008), De la pelle mécanique aux remontages lithiques: espace habité et techniques au Tardiglaciaire sur l’habitat des Chaloignes (Mozé-sur-Louet, Maine-et-Loire), Revue archéologique de l'Ouest, Vol. 25, pp. 7-52.

Martínez-Moreno, J., Mora, R., Casanova, J., (2006), El Mesolítico de los Pirineos surorientales: Una reflexión sobre el significado de las ‘facies de fortuna’del Postglaciar, in: Ruiz, A. A., (Eds.), El Mesolítico de muescas y denticulados en la cuenca del Ebro y el litoral mediterráneo peninsular. Memorias de Yacimientos Alaveses, 11, pp. 163-192.

Martínez-Moreno, J., Torcal, R. M., (2009), Balma Guilanyà (Prepirineo de Lleida) y el Aziliense en el noreste de la Península Ibérica, Trabajos de Prehistoria, Vol. 66:2, pp. 45-60.

Masferrer, N. S., (1980), El jaciment prehistòric de Coma d'Infern, a Les Encies (Les Planes, Girona), Cypsela, No. 3, pp. 31-65.

Mazo, C., Utrilla, P., (1996), Excavaciones en la cueva de Abauntz (Arraiz). Campañas de 1994 y 1995, Trabajos de Arqueologia Navarra, Vol. 12, pp. 270-279.

Michel, S., (2011), Le Pays-de-Retz au début du Mésolithique : le site des Vingt-Deux Boisselées-1 (Saint-Père-en-Retz, Loire-Atlantique), Revue archéologique de l'Ouest, Vol. 28, pp. 19-36.

Miller, R., Stewart, J., Nicolas, Z., Otte, M., (2007), The stratified Early to Late Mesolithic sequence at Trou Al'Wesse (Modave, Belgium), in: Crombé, P., Van Strydonck, M., Sergant, J., Mathieu, B., Machteld, B., (Eds.), Chronology and Evolution within the Mesolithic of North-West Europe: Proceedings of an International Meeting, Brussels, May 30th-June 1st, 2007, Cambridge Scholars Publishing, pp. 277-296.

Monroig, D. R., (2010), El jaciment epimagdalenià de la balma de la Roureda (Vilafranca, els Ports, País Valencià), Pyrenae, Vol. 41:2, pp. 7-28.

Monroig, D. R., (2012), El jaciment epimagdalenià de les Covarxelles (Tírig, Alt Maestrat, País Valencià), Archivo de Prehistoria Levantina, Vol. 29, pp. 121-140.

Monroig, D.R., (2010), Noves aportacions al Paleolític superior final en el nord del País Valencià: els jaciments de la serra d'Irta (Baix Maestrat). Archivo de Prehistoria Levantina, Vol. 28, pp. 73-89.

Montes, L., (2002), El abrigo epipaleolítico de Peña 14 (Biel, Zaragoza). Excavaciones 1999 y 2000, Salduie, Vol. 2, pp. 291-306.

Montoya, C., (2008), Les traditions techniques lithiques a l' Epigravettien: Analyses de s eries du Tardiglaciaire entre Alpes et Mediterranee, PhD Thesis, Université de Provence.

Montoya, C., (2008), Les traditions techniques lithiques a l' Epigravettien: Analyses de s eries du Tardiglaciaire entre Alpes et Mediterranee, PhD Thesis, Université de Provence.

Moree, J. M., Sier, M. M., (Eds.), (2015), Twenty metres deep! The Mesolithic period at the Yangtze Harbour site – Rotterdam Maasvlakte, the Netherlands. Early Holocene landscape development and habitation, Interdisciplinary Archaeological Research Programme Maasvlakte 2, Rotterdam, BOORrapporten 566.

Nicolas, E., Marchand, G., Deloze, V., Juhel, L., Vissac, C., (2012), Les occupations mésolithiques de Pen Hoat Salaün en Bretagne: premiers résultats de la fouille préventive et retour d'expérience sur les méthodes employées, Bulletin de la Société Préhistorique Française, Vol. 109:3, pp. 457-494.

Niekus, M. J. L. Th., de Roever, J. P., Smit, J. L., (1997), Een vroeg-mesolithische nederzetting met tranchetbijlen bij Lageland (Gr.), Paleo-aktueel, Vol. 8, pp. 28-32.

Niekus, M. J. L. Th., Stapert, D., (1994), Een vindplaats van de overgang Laat-Paleolithicum/Mesolithicum bij Oudega (FR.), Paleo-aktueel, Vol. 5, pp. 17-21.

Niekus, M., (2004), Een kampement van jager-verzamelaars van de Ahrensburg-traditie bij Hoogkerk, Hervonden stad, Vol. 9, pp. 83-94.

Otte, M., (1981), Le Paleolithique Final de Brou, Publication de la Societe Prehistorique Luxembourgerise, Le Mesolithique entre Rhin et Meuse, Actes du colloque sur le Paleolithique Superieur final le Mesolithique dans le Grand-Duche de Lumembourg et dans les regions voisins (Ardenne, Eifel, Lorraine), tenu a Luxembourg le 18 et 19 mai 1981, pp 331-342.

Otte, M., (1994), L'industrie lithique de Meer IV, Anthropologie et Prehistoire, Vol. 105, pp. 39-62.

Paddayya, K., (1973), A Federmesser Site with Tanged Points at Norgervaart prov. of Drenthe (Netherlands), Palaeohistoria, Vol. 15, pp. 167-213.

Pedersen, K. B., Petersen, E. B., (2006), Variability in the Late Palaeolithic: The example of Stoksbjerg Bro, Zealand, Denmark, in Hansen, K. M., Pedersen, K. B., (Eds.), (2006), Across the western Baltic: Proceedings from an archaeological conference in Vordingborg, pp. 75-92.

Perdaen. Y., Crombé, P., Sergant, J., (2008), Lithic Technology and the Cultural Identity of Early Mesolithic Groups, Current Anthropology, Vol. 49:2, pp. 317-327

Peresani, M., Astuti, P., Di Anastasio, G., Di Taranto, E, Duches, R., Masin, I., Miolo, R., (2011), Gli insediamenti epigravettiani e la frequentazione mesolitica attorno al Palughetto sull'Altopiano del Cansiglio (Prealpi Venete), Preistoria Alpina, Vol. 45, pp. 21-65.

Peresani, M., Bertola, S., (2010), Approvisionnement en matériaux siliceux, ressources locales et économie du débitage dans le Sauveterrien: Un exemple du Haut-Plateau du Cansiglio (Alpes orientales italiennes), Préhistoires Méditerranéennes, Vol. 1, pp. 87-99.

Peresani, M., Duches, R., Miolo, R., Romandini, M., Ziggiotti, S., (2009), Small specialized hunting sites and their role in Epigravettian subsistence strategies: A case study in Northern Italy, in: Bon, F., Costamagno, S., Valdeyron, N., (Eds.), Hunting Camps in Prehistory Current Archaeological Approaches, Proceedings of the International Symposium, May 13-15 2009, University Toulouse II, Palethnology, pp. 251-266.

Peresani, M., Ferrari, S., Miolo, R., Ziggiotti, S., (2009), Il sito di Casera Lissandri 17 e l'occupazione sauveterriana del versante occidentale di Piancansiglio, in: Peresani M., Ravazzi C., (Eds.), Le foreste dei cacciatori paleolitici. Ambiente e popolamento umano in

Cansiglio tra Tardoglaciale e Postglaciale, Supplemento al Bollettino Società Naturalisti Siliva Zenari, Pordenone, pp. 199-227.

Petersen, P. V., Johansen, L., (1991), Sølbjerg I – An Ahrensburgian site on a reindeer migration route through eastern Denmark, Journal of Danish Archaeology, Vol. 10, pp. 20-37.

Pion, G., (1997), L'abri de la Fru à Saint-Christophe-la-Grotte (Savoie): l'Azilien ancien du début de l'Alleröd, Bulletin de la Société Préhistorique Française, Vol. 94:3, pp. 319-326.

Price, T. D., Whallon, R. Jr., Chappell, S., (1974), Mesolithic sites near Havelte, province of Drenthe (Netherlands). A preliminary report of the Havelte Project (Museum of Anthropology, University of Michigan - Biologisch-Archaeologisch Instituut, State University of Groningen), Palaeohistoria, Vol. 16, pp. 58-59.

Prost, D., (2013), Le locus mésolithique de Muids, Le Gorgeon-des-Rues (Eure), Revue Archéologique de l'Ouest, Vol. 30, pp. 2-26.

Quesada, C. C., López, S. R., Pardo, J. F. J., Ibáñez, F. J. M., (2004), El registro arqueológico del Pleistoceno superior final en el abrigo de la Peña de Estebanvela (S de la Cuenca del Duero, Segovia, España), 11th Reunion Nacional de Cuaternario, 2-3 y 4 de Julio, 2003, pp. 191-198.

Quesada, C. C., López, S. R., Pardo, J. F. J., Ibáñez, F. J. M., (2004), El registro arqueológico del Pleistoceno superior final en el abrigo de la Peña de Estebanvela (S de la Cuenca del Duero, Segovia, España), 11th Reunion Nacional de Cuaternario, 2-3 y 4 de Julio, 2003, pp. 191-198.

Richter, P. B., (1992), Ein Spätglazialer Fundplatz auf dem Friedhof in Melbeck, Ldkr. Lüneburg, Nachrichten aus Niedersachsens Urgeschichte, Vol. 6, pp. 3-32.

Richter, P. B., (2002), Erste Ergebnisse der Ausgrabungen eines spätpaläolithische und endneolithischen Siedlungsareals bei Häcklingen, Ldkr. Lüneburg, Nachrichten aus Niedersachsens Urgeschichte, Vol. 71, pp. 3-28.

Riede, F., Grimm, S., Weber, M. J., Fahlke, J. M., (2010), Neue Daten für alte Grabungen: Ein Beitrag zur spätglazialen archäologie und Faunengeschichte Norddeutschlands, Archäologisches Korrespondenzblatt, Vol. 40:3, pp. 297-316.

Roman, D., (2010), Nuevos datos para la transición Pleistoceno-Holoceno: El abrigo del Cingle de l'Aigua (Xert, Baix Maestrat, País Valenciano), Zephyrus LXVI (2), pp. 203-212.

Ruiz, A. A., (1997), El yacimiento prehistórico de Kanpanoste Goikoa (Alava): Análisis industrial de los útiles sobre sílex y caracterización el Solsonès], Darreres investigacions al Pre-pirineu lleidatà 2009-2011.

Rust, A., (1943), Die alt- und mittelsteinzeitlichen Funde von Stellmoor, Neumünster in Holstein, K. Wachholtz.

Rust, A., (1958), Die Funde vom Pinnberg, Neumüunster, K. Wachholtz.

Saville, A., Ballin, T.B., Ward, T., (2007), Howburn, near Biggar, South Lanarkshire: Preliminary notice of a Scottish inland early Holocene lithic assemblage, Lithics: The Journal of the Lithic Studies Society, Vol. 28, pp. 41–49.

Sebastian, A. S., (2015), Los sistemas de producción lítica en el Epimagdaleniense y el Sauveterroide del Alto Ebro: El caso del abrigo de Atxoste (Vírgala, Álava, País Vasco), Antropologia-Arkeologia, No. 66, pp. 93-118.

Sicard-Marchand, S., Rouzean, M. H., Rouzean, M., (2004), 'La Vigie Romaine': Un site de la fin du Paleolithique Superieur sur la cote sauvage du Croisic (Loire-Atlantique), Revue Archeologique de L'Ouest, Vol. 21, pp. 5-17.

Skar, B., Coulson, S., (1989), A case study of Rormyr II: a Norwegian Early Mesolithic site, in: Bonsall, C., (Eds.), The Mesolithic of Europe: Papers presented at the third international symposium, Edinburgh 1985, pp. 351-361.

Sorensen, L., (2010), The Lacher See volcanic eruption: Challenging the idea of cultural dispersion, Acta Archaeologica, Vol. 81, pp. 270-281.

Sorensen, M., Sternke, F., (2004), Nørregård VI – Lateglacial hunters in transition, in Terberger, T., and Eriksen, B. V., (Eds), (2004), Hunters in a changing world: Environment and archaeology of the Pleistocene – Holocene transition (ca. 11,000 – 9,000 BC) in Northern Central Europe, Arbeitsgemeinschait Symposium Tagung Knogress 5, 85-111.

Soto, A., Alday, A., Montes, L., Utrilla, P., Perales, U., Domingo, R., (2015), Epipalaeolithic assemblages in the Western Ebro Basin (Spain): The difficult identification of cultural entities, Quaternary International, Vol. 364, pp. 144-152.

Souffi, B., (2004), Le Mésolithique en Haute-Normandie (France) L'exemple du site d'Acquigny, l'Onglais (Eure) et sa contribution à l'étude des gisements mésolithiques de plein air, BAR International Series 1307.

Souffi, B., Guéret, C., Guillemard, I., Leduc, C., (2015), Le site Mésolithique de Rosnay, Haut-de-Vallière (Marne): Une occupation spécialisée du premier Mésolithique, Bulletin de la Société Préhistorique Française, Vol. 112:4, pp. 717-759.

Stapert, D., (1998), Two Epi-Ahrensburgian sites in the Northern Netherlands: Oudehaske and Gramsbergen, Palaeohistoria, Vol. 39-40, pp. 1-87.

Stoop, D. D. L., (2014), Federmesser mobility patterns in the Western Meuse area, Limburg, the Netherlands: the case studies of Horn-Haelen and Heythuysen-de Fransman I, Masters Thesis, University of Leiden.

Straus, L. G., (1987), Terminal Paleolithic and Early Mesolithic research at Abri Dufaure, southwest France, Anthropologia y Archeologia, Vol. 39, pp. 61-65.

Straus, L. G., Clark, G. A., (1986), La Riera Cave: Stone age hunter-gatherer adaptations in northern Spain, Anthropological Research Papers No. 36, Arizona State University.

Takala, H., (2003), Recent excavations at the Pre-boreal site of Lahti, Ristola in southern Finland, in: Larsson, L., Kindgren, H., Knutsson, K., Loeffler, D., Akerlund, A., (Eds.), Mesolithic on the move: Papers presented at the Sixth International Conference on the Mesolithic in Europe, Stockholm 2000, Oxbow Books, pp. 684-687.

Teyssandier, N., (2000), Un gisement belloisien sur les bords de la Seine: le Closeay àRueil-Malmaison (Hauts-de-Seine), Bulletin de la Société préhistorique française, Vol. 97:2, pp. 211-228.

Tromnau, G., (1973), Neue Ausgrabungen von jungpaläolithischen Wohnplätzen auf der Teltwisch bei Ahrensburg, Kreis Stormarn (Schleswig-Holstein), Archäologische Informationen, Vol. 1, pp. 49-53.

Utrilla, P., Domingo, R., (2003), Yacimientos Magdalenienses en Cetina (Zaragoza): Los dos abrigos de la Peña del Diablo, Salduie, Vol. 3, pp. 15-45.

Utrilla, P., Mazo, C., (1991), Excavación de urgencia en el abrigo de Las Forcas (Graus-Huesca): Las ocupaciones magdaleniense y epipaleolítica, Bolskan, Vol. 8, pp. 31-78.

Valentin, B., (1992), Les groupes humains et leurs traditions au Tardiglaciaire dans le Bassin Parisen: Apports de la technologie lithique comparee, PhD thesis, Univesity of Paris

Valentin, B., (1992), Les groupes humains et leurs traditions au Tardiglaciaire dans le Bassin Parisen: Apports de la technologie lithique comparee, PhD thesis, Univesity of Paris

Valentin, B., Fosse, G., Billard, C., (2004), Aspects et rythmes de l'azilianisation dans le Bassin parisien [Caractérisation de l'industrie lithique recueillie au Cornet (locus 33) à Ambenay, Eure], Gallia préhistoire, Vol. 46, pp. 171-209.

Vanmontfort, B., Van Gils, M., Paulissen, E., Bastiaens, J., De Bie, M., Meirsman, E., (2010), Human occupation of the Late and Early Post-Glacial environments in the Liereman Landscape (Campine, Belgium), Journal of Archaeology in the Low Countries, Vol. 2:2, pp. 31-51.

Vaquero, M., Alonso, S., García-Catalán, S., García-Hernández, A., de Soler, B.G., Rettig, D., Soto, M., (2012), Temporal nature and recycling of Upper Paleolithic artifacts: the burned tools from the Molí del Salt site (Vimbodí i Poblet, northeastern Spain), Journal of Archaeological Science, Vol. 39:8, pp. 2785-2796.

Veil, S., (1987), Ein Fundplatz der Stielspitzen-Gruppen ohne Stielspitzen bei Hofer, Ldkr. Celle. Ein Beispiel funktionaler Variabilität paläolithischer Steinartefaktinventare, Archäologisches Korrespondenzblatt, Vol. 17:3, pp. 311-322.

Veil, S., Breest, K., (1994), Le gisement Federmesser de Weitsche, LDKR. Luchow-Dannenberg, Allemagne: Structures spatiales, typologie et manifestations esthetiques, in

Fagnart, J. P., Thevenin, A., (Eds), Le Tardiglaciare en Europe du Nord-West, Actes du 119th Congres National des Societes Historiques et Scientifiques, pp. 589-609.

Verges, J.M., Allué, E., Fontanals, M., Morales, J.I., Martín, P., Carrancho, Á., Expósito, I., Guardiola, M., Lozano, M., Marsal, R., Oms, X., (2016),. El Mirador cave (Sierra de Atapuerca, Burgos, Spain): A whole perspective, Quaternary International, Vol. 414, pp. 236-243.

Verhart, L. B. M., (1995), An Early Mesolithic hunting camp at Posterholt, Municipality of Ambt Montford (The Netherlands), Mesolithic Miscellany, Vol. 16:2, pp. 20-29.

Vermeersch, P. M., (1972), Twee Mesolithische sites te Holsbeek, Archaeologica Belgica 138, Brussels.

Vermeersch, P. M., (1974), Epipaleolithicum en Mesolithicum te Helchteren, Sonnisse Heide, Archaeologica Belgica 169, Brussels.

Vermeersch, P. M., (1976), Un site Tjongerien à Harelbeke, Gavermeersen, Westvlaamse Archaeologica, Vol. 4, pp. 13-71

Vermeersch, P. M., (2008), La transition Ahrensbourgien-Mésolithique ancien en Campine belge et dans le sud sableux des Pays-Bas, Société préhistorique française, in : Fagnart, J. P., Thevenin, A., Ducrocq, T., Souffi, B., Coudret, P., (Eds.), Le début du Mésolithique en Europe du Nord-Ouest, Actes de la table ronde d'Amiens 9-10 Octobre 2004, pp. 11-30.

Vermeersch, P. M., (2013), An Ahrensburgian Site at Zonhoven-Molenheide (Belgium),BAR International Series 2471, Oxford, Archaeopress.

Vermeersch, P. M., Carlous, J., (1975), Un site mésolithique à Linkhout-Kampbergen (Limbourg belge), Bulletin de la Société Préhistorique Française, Vol. 72:4, pp. 125-128.

Visentin, D., Fontana, F., Bertola, S., (2014), An Atypical Early Mesolithic Occupation in the Southern Po Plain: Evidence from the Site of Collecchio (Parma, Italy), in Henry A., Marquebielle B., Chesnaux L., Michel S. (Eds.), Techniques and Territories: New Insights into Mesolithic Cultures, Proceedings of the Round table, November 22-23 2012, Maison de la recherche, Toulouse (France), P@lethnology, Vol. 6, pp. 123-128.

Von Heinrich Maack, Z., (1977), Neur Flintplatz des Ahrensburg-Lavenstedter Kulturkreises in der Gemarkung Rockstedt, Kr. Bremervorde, Die Kunde, Vol. 28-29, pp. 3-5.

Votquenne, S., (1994), Données nouvelles sur le site mésolithique de Sougné A (Sougné-Remouchamps), Notae praehistoricae, Vol. 14, pp. 81-84.

Vukosavljević, N., Perhoč, Z., (2017), Lithic raw material procurement of the Late Epigravettian hunter-gatherers from Kopačina Cave (island of Brač, Dalmatia, Croatia), Quaternary International, Vol. 450, pp. 164-185.

Vynckier, G., Vermeersch, P. M., (1985), Opgraving van een Oud-Mesolithisch site te Donk, Archaeologica Belgica, Vol. 1:2, pp. 13-16.

Watte, J. P., (2008), Le fond du Boscol, a Hericourt-en-Caux (Seine-Maritime): Un gisement Paleolithique Superieur Final, Mesolithique, et Neolithique, Haute-Normandie Archéologique, Bullitin 13:1, pp. 41-56.

Watte, J. P., (2010), Etude du materiel lithique recueilli lors de l'operation de diagnostic du contournement routier de Gisors (Eure), Haute-Normandie Archéologique, No. 15, pp. 19-33.

Watte, J. P., (2013), Un important habitat azilien en seine-maritime: le paulu à Saint-Paër, in Journée du CReAAH, Archéologie, Archéosciences, Histoire, Rennes, March 16th, 2013, pp. 11-12.

Weber, M. J., Clausen, I., Housley, R. A., Miller, C. E., Riede, F., Usinger, H., (2010), New information on the Havelte Group site Ahrenshöft LA 58 D (Nordfriesland, Germany) - Preliminary results of the 2008 fieldwork, Quartär, Vol. 57, pp. 7-27.

Wenzel, S., (2009), Behausungen im Späten Jungpaläolithikum und im Mesolithikum in Nord-, Mittel- und Westeuropa, Monographien des Römisch-Germanischen Zentralmuseums 81. Mainz & Bonn.

Wymer, J. J., Robins, T., (1994), A Long Blade flint industry beneath Boreal peat at Titchwell, Norfolk, Norfolk Archaeology, Vol. 42:1, pp. 13-37.

Wymer, J., (1976), A Long Blade industry from Sproughton, Suffolk, East Anglian Archaeology, Report No. 3, pp 1-10.

Appendix 3

Statistical Calculations

Northwest European Dataset

A3.1: NTAXA

Kruskal-Wallis rank sum test: (H(2) = 2.046, df = 2, p-value = 0.360).

Mann-Whitney U Test (Two-Tailed)

Compared Means	W Value	p	Significance
Allerød and YD	1908.5	0.494	Not significant
YD and PB	1830	0.140	Not significant
Allerød and PB	2564	0.442	Not significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	0.740	0.689	Not significant
YD and PB	1.419	0.234	Not significant
Allerød and PB	-0.810	0.627	Not significant

A3.2: Simpsons Index

Kruskal-Wallis rank sum test: (H(2) = 13.332, df = 2, p-value = 0.001).

Mann-Whitney U Test (Two-Tailed)

Compared Means	W Value	p	Significance
Allerød and YD	2374	0.001	Significant
YD and PB	1701	0.391	Not significant
Allerød and PB	3418	0.005	Significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	3.298	0.002	Significant
YD and PB	0.814	0.623	Not significant
Allerød and PB	2.791	0.008	Significant

A3.3: Total Number of Artefacts per m^2

Kruskal-Wallis rank sum test: (H(2) = 2.163, df = 2, p-value = 0.339).

Mann-Whitney U Test (Two-Tailed)

Compared Means	W Value	p	Significance
Allerød and YD	586.5	0.242	Not significant
YD and PB	631	0.964	Not significant
Allerød and PB	771	0.193	Not significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	-1.207	0.341	Not significant
YD and PB	-0.017	1.000	Not significant
Allerød and PB	-1.286	0.298	Not significant

A3.4: Total Number of Artefacts

Kruskal-Wallis rank sum test: ($H(2) = 7.640$, df = 2, p-value = 0.022).

Mann-Whitney U Test (Two-Tailed)

Compared Means	W Value	p	Significance
Allerød and YD	1793.5	0.643	Not significant
YD and PB	1977	0.118	Not significant
Allerød and PB	1930.5	0.004	Significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	-0.648	0.775	Not significant
YD and PB	-2.705	0.116	Not significant
Allerød and PB	-2.705	0.010	Significant

A3.5: Percentage of Microliths in Total Assemblage

Kruskal-Wallis rank sum test: (H(2) = 56.341, df = 2, p-value = <0.00001).

Mann-Whitney U Test (Two-Tailed)

Compared Means	W Value	p	Significance
Allerød and YD	1304	0.0002	Significant
YD and PB	2342	0.0002	Significant
Allerød and PB	990.5	<0.00001	Significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	-3.013	0.004	Significant
YD and PB	3.711	<0.00001	Significant
Allerød and PB	-7.503	<0.00001	Significant

A3.6: Percentage of Microliths in Tool Assemblage

Kruskal-Wallis rank sum test: (H(2) = 64.822, df = 2, p-value = <0.00001).

Mann-Whitney U Test (Two-Tailed)

Compared Means	W Value	p	Significance
Allerød and YD	1204.5	<0.00001	Significant
YD and PB	2318.5	0.001	Significant
Allerød and PB	1034.5	<0.00001	Significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	-3.587	0.001	Significant
YD and PB	3.337	0.001	Significant
Allerød and PB	-8.046	<0.00001	Significant

A3.7: Blank to Tool Ratio: Excluding Sites with Unknown Excavation Dates

Kruskal-Wallis rank sum test: (H(2) = 10.432, df = 2, p-value = 0.005)

Mann-Whitney U Test (Two-Tailed)

Compared Means	W Value	p	Significance
Allerød and YD	477.5	0.002	Significant
YD and PB	645	0.042	Significant
Allerød and PB	1548	0.112	Not significant

Dunn's Test (with Bonferroni correction)

Compared Means	W Value	p	Significance
Allerød and YD	385.5	0.004	Significant
YD and PB	631	0.039	Significant
Allerød and PB	1273	0.343	Not significant

A3.8: Blank to Tool Ratio: Including Sites with Unknown Excavation Dates

Kruskal-Wallis rank sum test: (H(2) = 8.092, df = 2, p-value = 0.018).

Mann-Whitney U Test (Two-Tailed)

Compared Means	Z	p	Significance
Allerød and YD	-3.218	0.002	Significant
YD and PB	-2.001	0.068	Not significant
Allerød and PB	-1.567	0.176	Not significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	-2.821	0.007	Significant
YD and PB	-2.123	0.051	Near significant
Allerød and PB	-0.990	0.483	Not significant

A3.9: Blank to Core Ratio

Kruskal-Wallis rank sum test: (H(2) = 8.231, df = 2, p-value = 0.016).

Mann-Whitney U Test (Two-Tailed)

Compared Means	W Value	p	Significance
Allerød and YD	733	0.008	Significant
YD and PB	910	0.024	Significant
Allerød and PB	1505.5	0.352	Not significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	-2.809	0.008	Significant
YD and PB	-2.132	0.050	Significant
Allerød and PB	-0.825	0.614	Not significant

A3.10: Percentage of Utilised and Retouched Blanks in the Total Assemblage

Kruskal-Wallis rank sum test: (H(2) = 6.745, df = 2, p-value = 0.034).

Mann-Whitney U Test (Two-Tailed)

Compared Means	W Value	p	Significance
Allerød and YD	1103	0.013	Significant
YD and PB	1223	0.031	Significant
Allerød and PB	1625	0.707	Not significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	2.470	0.020	Significant
YD and PB	2.189	0.043	Significant
Allerød and PB	0.400	1.000	Not significant

A3.11: Percentage of Utilised and Retouched Blanks in the Tool Assemblage

Kruskal-Wallis rank sum test: (H(2) = 5.363, df = 2, p-value = 0.068).

Mann-Whitney U Test (Two-Tailed)

Compared Means	W Value	p	Significance
Allerød and YD	1028.5	0.252	Not significant
YD and PB	1346	0.019	Significant
Allerød and PB	1593.5	0.240	Not significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	1.225	0.331	Not significant
YD and PB	2.288	0.033	Significant
Allerød and PB	-1.222	0.333	Not significant

A3.12: Tool to Core Ratio

Kruskal-Wallis rank sum test: (H(2) = 1.765, df = 2, p-value = 0.414).

Mann-Whitney U Test (Two-Tailed)

Compared Means	W Value	p	Significance
Allerød and YD	1081	0.258	Not significant
YD and PB	962	0.215	Not significant
Allerød and PB	1843.5	0.951	Not significant

Dunn’s Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	-1.217	0.336	Not significant
YD and PB	-1.165	0.366	Not significant
Allerød and PB	-0.085	1.000	Not significant

A3.13: Base Camp Analysis: Blank to Tool Ratio Comparisons

Kruskal-Wallis rank sum test: (H(2) = 10.423, df = 2, p-value = 0.005).

Mann-Whitney U Test (Two-Tailed)

Compared Means	W Value	p	Significance
Allerød and YD	300.5	0.014	Significant
YD and PB	213	0.001	Significant
Allerød and PB	1044	0.287	Not significant

Dunn’s Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	-2.425	0.023	Significant
YD and PB	-3.207	0.002	Significant
Allerød and PB	1.044	0.445	Not significant

A3.14: Base Camp Analysis: Blank to Core Ratio Comparisons

Kruskal-Wallis rank sum test: (H(2) = 11.802, df = 2, p-value = 0.003).

Mann-Whitney U Test (Two-Tailed)

Compared Means	W Value	p	Significance
Allerød and YD	213	0.0008	Significant
YD and PB	225	0.008	Significant
Allerød and PB	680	0.345	Not significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	-3.402	0.001	Significant
YD and PB	-2.579	0.015	Significant
Allerød and PB	-0.908	0.546	Not significant

A3.15: Base Camp Analysis: Tool to Core Ratio Comparisons

Kruskal-Wallis rank sum test: (H(2) = 4.227, df = 2, p-value = 0.121).

Mann-Whitney U Test (Two-Tailed)

Compared Means	W Value	p	Significance
Allerød and YD	314	0.039	Significant
YD and PB	328	0.332	Not significant
Allerød and PB	700.5	0.284	Not significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	-2.023	0.065	Not significant
YD and PB	-1.051	0.440	Not significant
Allerød and PB	-1.118	0.396	Not significant

A3.16: Special Task Camp Analysis: Blank to Tool Ratio Comparisons

Kruskal-Wallis rank sum test: (H(2) = 12.612, df = 2, p-value = 0.002).

Mann-Whitney U Test (Two-Tailed)

Compared Means	W Value	p	Significance
Allerød and YD	174	0.020	Significant
YD and PB	347	0.452	Not significant
Allerød and PB	161	0.0005	Significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	-2.413	0.024	Significant
YD and PB	0.846	0.596	Not significant
Allerød and PB	-3.451	0.0008	Significant

A3.17: Special Task Camp Analysis: Blank to Core Ratio Comparisons

Kruskal-Wallis rank sum test: (H(2) = 1.235, df = 2, p-value = 0.539).

Mann-Whitney U Test (Two-Tailed)

Compared Means	W Value	p	Significance
Allerød and YD	245.5	0.265	Not significant
YD and PB	271.5	0.615	Not significant
Allerød and PB	183.5	0.578	Not significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	0.607	0.816	Not significant
YD and PB	-0.534	0.890	Not significant
Allerød and PB	1.107	0.403	Not significant

A3.18: Special Task Camp Analysis: Blank to Core Ratio Comparisons

Kruskal-Wallis rank sum test: (H(2) = 5.755, df = 2, p-value = 0.056).

Mann-Whitney U Test (Two-Tailed)

Compared Means	W Value	p	Significance
Allerød and YD	207.5	0.359	Not significant
YD and PB	232	0.140	Not significant
Allerød and PB	318.5	0.022	Significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	0.928	0.530	Not significant
YD and PB	-1.483	0.207	Not significant
Allerød and PB	2.321	0.030	Significant

A3.19: Comparison of Base camps and Special Task Camps: Blank to Tool Ratio

Mann-Whitney U Test (Two-Tailed)

Compared B/T Means	W Value	p	Significance
Allerød Base Camps and Special Task Camps	791	0.055	Significant?
YD Base Camps and Special Task Camps	220	0.522	Not significant
PB Base Camps and Special Task Camps	527	0.551	Not significant

A3.20: Comparison of Base camps and Special Task Camps: Blank to Core Ratio

Mann-Whitney U Test (Two-Tailed)

Compared B/T Means	W Value	p	Significance
Allerød Base Camps and Special Task Camps	260	0.089	Not significant
YD Base Camps and Special Task Camps	245	0.273	Not significant
PB Base Camps and Special Task Camps	497	0.894	Not significant

A3.21: Comparison of Base camps and Special Task Camps: Tool to Core Ratio

Mann-Whitney U Test (Two-Tailed)

Compared B/T Means	W Value	p	Significance
Allerød Base Camps and Special Task Camps	329.5	0.272	Not significant
YD Base Camps and Special Task Camps	190	0.777	Not significant
PB Base Camps and Special Task Camps	562	0.602	Not significant

South European Dataset

A3.22: NTAXA

Kruskal-Wallis rank sum test: (H(2) = 0.696, df = 2, p-value = 0.706).

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
Allerød and YD	901.5	0.518	Not significant
YD and PB	795.5	0.440	Not significant
Allerød and PB	856.5	0.851	Not significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	0.642	0.782	Not significant
YD and PB	0.793	0.642	Not significant
Allerød and PB	-0.181	1.000	Not significant

A3.23: Simpsons Index

Kruskal-Wallis rank sum test: (H(2) = 9.000, df = 2, p-value = 0.011).

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
Allerød and YD	785	0.661	Not significant
YD and PB	441	0.004	Significant
Allerød and PB	1128.5	0.025	Significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	-0.558	0.865	Not significant
YD and PB	-2.794	0.008	Significant
Allerød and PB	2.365	0.027	Significant

A3.24: Total Artefacts per m^2

Kruskal-Wallis rank sum test: (H(2) = 2.719, df = 2, p-value = 0.257).

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
Allerød and YD	425	0.155	Not significant
YD and PB	344	0.152	Not significant
Allerød and PB	356	0.952	Not significant

Dunn’s Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	1.446	0.222	Not significant
YD and PB	1.445	0.223	Not significant
Allerød and PB	-0.076	1.000	Not significant

A3.25: Total Number of Artefacts

Kruskal-Wallis rank sum test: (H(2) = 0.801, df = 2, p-value = 0.670).

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
Allerød and YD	469.5	0.595	Not significant
YD and PB	401	0.368	Not significant
Allerød and PB	367.5	0.748	Not significant

Dunn’s Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	0.564	0.859	Not significant
YD and PB	0.883	0.566	Not significant
Allerød and PB	-0.357	1.000	Not significant

A3.26: Percentage Microliths in Total Assemblage

Kruskal-Wallis rank sum test: (H(2) = 30.625, df = 2, p-value = <0.00001).

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
Allerød and YD	360	0.191	Not significant
YD and PB	546	<0.00001	Significant
Allerød and PB	96	<0.00001	Significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	-0.981	0.4902	Not significant
YD and PB	4.273	<0.00001	Significant
Allerød and PB	-5.281	<0.00001	Significant

A3.27: Percentage of Microliths in Tool Assemblage

Kruskal-Wallis rank sum test: (H(2) = 37.825, df = 2, p-value = <0.00001).

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
Allerød and YD	696	0.086	Not significant
YD and PB	1219	<0.00001	Significant
Allerød and PB	364	<0.00001	Significant

Dunn’s Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	-1.220	0.334	Not significant
YD and PB	4.399	<0.00001	Significant
Allerød and PB	-5.895	<0.00001	Significant

A3.28: Blank to Tool Ratio

Kruskal-Wallis rank sum test: (H(2) = 2.073, df = 2, p-value = 0.355).

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
Allerød and YD	313	0.153	Not significant
YD and PB	307	0.744	Not significant
Allerød and PB	333	0.376	Not significant

Dunn’s Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	-1.392	0.246	Not significant
YD and PB	-0.404	1.000	Not significant
Allerød and PB	-0.956	0.509	Not significant

A3.30: Blank to Core Ratio

Kruskal-Wallis rank sum test: (H(2) = 7.193, df = 2, p-value = 0.027).

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
Allerød and YD	227	0.933	Not significant
YD and PB	351	0.024	Significant
Allerød and PB	158	0.019	Significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	-0.080	1.000	Not significant
YD and PB	2.244	0.037	Significant
Allerød and PB	-2.355	0.028	Significant

A3.31: Percentage of Retouched and Utilised Blanks in Total Assemblage

Kruskal-Wallis rank sum test: (H(2) = 11.057, df = 2, p-value = 0.004).

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
Allerød and YD	147	0.157	Not significant
YD and PB	62	0.003	Significant
Allerød and PB	227	0.009	Significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	-1.153	0.372	Not significant
YD and PB	-3.299	0.002	Significant
Allerød and PB	2.229	0.039	Significant

A3.32: Percentage of Retouched and Utilised Blanks in Tool Assemblage

Kruskal-Wallis rank sum test: ($H(2) = 5.830$, df = 2, p-value = 0.054).

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
Allerød and YD	229	0.110	Not significant
YD and PB	175	0.020	Significant
Allerød and PB	357	0.388	Not significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	-1.582	0.171	Not significant
YD and PB	-2.376	0.026	Significant
Allerød and PB	0.841	0.600	Not significant

A3.33: Tool to Core Ratio

Kruskal-Wallis rank sum test: (H(2) = 5 8.242, df = 2, p-value = 0.016).

Mann-Whitney U Test (Two-Tail)

Compared Means	**W Value**	**p**	**Significance**
Allerød and YD	368	0.412	Not significant
YD and PB	507.5	0.004	Significant
Allerød and PB	279	0.066	Not significant

Dunn's Test (with Bonferroni correction)

Compared Means	**Z**	**p**	**Significance**
Allerød and YD	0.911	0.543	Not significant
YD and PB	2.785	0.008	Significant
Allerød and PB	-1.918	0.083	Not significant

A3.34: Base Camp Analysis: Blank to Tool Ratio Comparisons

Kruskal-Wallis rank sum test: (H(2) = 0.776, df = 2, p-value = 0.679).

Mann-Whitney U Test (Two-Tail)

Compared Means	**W Value**	**p**	**Significance**
Allerød and YD	52	0.516	Not significant
YD and PB	27	0.500	Not significant
Allerød and PB	23	1.000	Not significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	-0.718	0.709	Not significant
YD and PB	-0.713	0.713	Not significant
Allerød and PB	0.116	1.000	Not significant

A3.35: Base Camp Analysis: Blank to Core Ratio Comparisons

Kruskal-Wallis rank sum test: (H(2) = 0.235, df = 2, p-value = 0.889).

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
Allerød and YD	63	0.794	Not significant
YD and PB	36	0.775	Not significant
Allerød and PB	19	0.699	Not significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	0.211	1.000	Not significant
YD and PB	0.483	0.944	Not significant
Allerød and PB	-0.291	1.000	Not significant

A3.36: Base Camp Analysis: Tool to Core Ratio Comparisons

Kruskal-Wallis rank sum test: (H(2) = 0.568, df = 2, p-value = 0.753).

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
Allerød and YD	83	0.472	Not significant
YD and PB	54	0.743	Not significant
Allerød and PB	37	0.887	Not significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	0.740	0.689	Not significant
YD and PB	0.407	1.000	Not significant
Allerød and PB	0.239	1.000	Not significant

A3.37: Special Task Camp Analysis: Blank to Tool Ratio Comparisons

Kruskal-Wallis rank sum test: (H(2) = 3.369, df = 2, p-value = 0.186).

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
Allerød and YD	79	0.082	Not significant
YD and PB	84	0.599	Not significant
Allerød and PB	129	0.241	Not significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	-1.743	0.122	Not significant
YD and PB	-0.592	0.831	Not significant
Allerød and PB	-1.220	0.334	Not significant

A3.38: Special Task Camp Analysis: Blank to Core Ratio Comparisons

Kruskal-Wallis rank sum test: ($H(2) = 3.481$, df = 2, p-value = 0.175).

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
Allerød and YD	61	0.726	Not significant
YD and PB	83	0.379	Not significant
Allerød and PB	66	0.056	Not significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	-0.527	0.897	Not significant
YD and PB	1.068	0.428	Not significant
Allerød and PB	-1.841	0.098	Not significant

A3.39: Special Task Camp Analysis: Tool to Core Ratio Comparisons

Kruskal-Wallis rank sum test: ($H(2) = 2.934$, df = 2, p-value = 0.231).

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
Allerød and YD	85	0.816	Not significant
YD and PB	115	0.141	Not significant
Allerød and PB	98	0.179	Not significant

Dunn's Test (with Bonferroni correction)

Compared Means	Z	p	Significance
Allerød and YD	0.284	1.000	Not significant
YD and PB	1.499	0.201	Not significant
Allerød and PB	-1.38	0.249	Not significant

A3.40: Comparison of Base camps and Special Task Camps: Blank to Tool Ratio

Mann-Whitney U Test (Two-Tail)

Compared B/T Means	W Value	p	Significance
Allerød Base Camps and Special Task Camps	72	0.326	Not significant
YD Base Camps and Special Task Camps	58	0.193	Not significant
PB Base Camps and Special Task Camps	PB sample too low	PB sample too low	PB sample too low

A3.41: Comparison of Base camps and Special Task Camps: Blank to Core Ratio

Mann-Whitney U Test (Two-Tail)

Compared B/C Means	W Value	p	Significance
Allerød Base Camps and Special Task Camps	55.5	0.493	Not significant
YD Base Camps and Special Task Camps	43	0.324	Not significant
PB Base Camps and Special Task Camps	PB sample too low	PB sample too low	PB sample too low

A3.42: Comparison of Base camps and Special Task Camps: Tool to Core Ratio

Mann-Whitney U Test (Two-Tail)

Compared T/C Means	W Value	p	Significance
Allerød Base Camps and Special Task Camps	97.5	0.737	Not significant
YD Base Camps and Special Task Camps	78	0.979	Not significant
PB Base Camps and Special Task Camps	28	0.183	Not significant

Northwest-South Dataset Comparisons

A3.43: NTAXA

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
NW Allerød and S Allerød	1327	0.018	Significant
NW YD and S YD	616.5	0.041	Significant
NW PB and S PB	1079	0.067	Not significant

A3.44: Simpsons Index

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
NW Allerød and S Allerød	1986	0.226	Not significant
NW YD and S YD	583	0.020	Significant
NW PB and S PB	1598	0.142	Not significant

A3.45: Total Number of Artefacts per m^2

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
NW Allerød and S Allerød	294	<0.00004	Significant
NW YD and S YD	299	0.322	Not significant
NW PB and S PB	292	0.006	Significant

A3.46: Total Number of Artefacts

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
NW Allerød and S Allerød	910	0.055	Near significant
NW YD and S YD	643	0.653	Not significant
NW PB and S PB	853	0.939	Not significant

A3.47: Percentage Microliths in Total Assemblage

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
NW Allerød and S Allerød	1157	0.987	Not significant
NW YD and S YD	751	0.433	Not significant
NW PB and S PB	524.5	0.007	Significant

A3.48: Percentage of Microliths in Tool Assemblage

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
NW Allerød and S Allerød	1934	0.877	Not significant
NW YD and S YD	1082.5	0.088	Not significant
NW PB and S PB	1371	0.095	Not significant

A3.49: Blank to Tool Ratio

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
NW Allerød and S Allerød	1054	0.453	Not significant
NW YD and S YD	435	0.224	Not significant
NW PB and S PB	762	0.817	Not significant

A3.50: Blank to Core Ratio

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
NW Allerød and S Allerød	569	0.399	Not significant
NW YD and S YD	535	0.396	Not significant
NW PB and S PB	432	0.001	Significant

A3.51: Percentage of Retouched and Utilised Blanks in Total Assemblage

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
NW Allerød and S Allerød	742	0.005	Significant
NW YD and S YD	269	0.345	Not significant
NW PB and S PB	763	<0.0001	Significant

A3.52: Percentage of Retouched and Utilised Blanks in Total Assemblage

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
NW Allerød and S Allerød	1056	0.001	Significant
NW YD and S YD	395	0.862	Not significant
NW PB and S PB	1302	<0.0001	Significant

A3.53: Tool to Core Ratio

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
NW Allerød and S Allerød	595	0.077	Not significant
NW YD and S YD	491.5	0.745	Not significant
NW PB and S PB	472	0.0002	Significant

A3.54: Base Camp Analysis Comparison: Blank to Tool Ratio

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
NW vs S Allerød Base Camps	236	0.315	Not significant
NW vs S YD Base Camps	120	0.169	Not significant
NW vs S PB Base Camps	85	0.025	Very low PB sample size

A3.55: Base Camp Analysis Comparison: Blank to Core Ratio

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
NW vs S Allerød Base Camps	118	0.158	Not significant
NW vs S YD Base Camps	116	0.113	Not significant
NW vs S PB Base Camps	51	0.669	Not significant

A3.56: Base Camp Analysis Comparison: Tool to Core Ratio

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
NW vs S Allerød Base Camps	120	0.053	Not significant
NW vs S YD Base Camps	86.5	0.846	Not significant
NW vs S PB Base Camps	54	0.381	Not significant

A3.57: Special Task Camp Analysis Comparison: Blank to Tool Ratio

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
NW vs S Allerød Special Task Camps	224	0.117	Not significant
NW vs S YD Special Task Camps	159	0.573	Not significant
NW vs S PB Special Task Camps	273	0.354	Not significant

A3.58: Special Task Camp Analysis Comparison: Blank to Core Ratio

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
NW vs S Allerød Special Task Camps	122.5	0.499	Not significant
NW vs S YD Special Task Camps	126	0.781	Not significant
NW vs S PB Special Task Camps	136	0.001	Significant

A3.59: Special Task Camp Analysis Comparison: Tool to Core Ratio

Mann-Whitney U Test (Two-Tail)

Compared Means	W Value	p	Significance
NW vs S Allerød Special Task Camps	165	0.675	Not significant
NW vs S YD Special Task Camps	172	0.977	Not significant
NW vs S PB Special Task Camps	172	0.002	Low PB sample size