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Exploring the land: a comparison of land-use patterns in the Middle and Upper Paleolithic of the western Mediterranean

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Abstract

By examining the patterning of artifacts across a physical landscape, prehistoric behavior regarding choice in land-use can be delineated. Using survey data from three valleys in eastern Spain, the Polop Alto, the Penaguila, and the Alcalá, we evaluate patterns in land-use for the Middle and Upper Paleolithic. Significant differences between the two time periods would support the idea that the transition from the Middle to the Upper Paleolithic coincided with changes in land-use. Geographic variables, including slope, aspect, and elevation of occupied portions of the landscape are used to determine land-use patterning; lithic analysis is also used to determine the extent of mobility and artifact curation, behaviors that are closely tied to land-use. Results indicate that occupation of the valleys of Mediterranean Spain was spatially patterned in relation to topography. A significant difference exists between intensively occupied and moderately occupied areas within time periods. However, there is little evidence for a difference in land-use between the Middle and Upper Paleolithic for any of the three valleys.

Keywords: Middle Paleolithic; Upper Paleolithic; Mediterranean Spain; Land-use; Mobility; Survey data

The origin of modern humans is a topic that has been approached from different bio-behavioral perspectives, with archaeology focusing on the artifactual indicators for the emergence of behavioral modernity. While behavioral modernity is an ambiguous concept, in Eurasia it has traditionally been associated with the transition from the Middle to the Upper Paleolithic lithic industries. Archaeologists have typically developed trait lists of behaviors to infer modernity. These lists include such elements as standardization of lithics, presence of art, intentional burials, bone artifacts, blade technology, compound tools, abstract thinking, planning depth, and innovation (McBrearty and Brooks, 2000; Mellars, 1989). Many of the elements of these trait lists have been disputed as clear cut markers of the Upper Paleolithic, modern humans, or modern behavior (e.g., Bar-Yosef and Kuhn, 1999; Clark, 1999).

Nevertheless, there are notable changes in both human biology and technology across the latter half of the Upper Pleistocene. Technology especially serves to mediate between humans and the environment and is an essential means by which humans acquire and process resources critical to their survival. Technological change then indicates change in the way humans interacted with their environment. For Upper Pleistocene hunter-gatherers, such changing adaptations almost certainly entailed shifts in land-use strategies—the way individuals and groups organized themselves and their movements across the landscape. However, little in the way of archaeological research has been focused upon change in Upper Pleistocene land-use practices. The research described here examines evidence for land-use patterns across the Middle to Upper Paleolithic transition in relation to behavioral modernity.

1. Background on Paleolithic research in Spain

The Iberian peninsula is an intriguing area for Paleolithic research because of the timing of the Middle/Upper Paleolithic transition (Vaquero and Carbonell, 2000). While chronology is, as always, problematic, Middle Paleolithic industries appear to have persisted in the south for at least 10,000 years

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after the Upper Paleolithic Aurignacian industries appeared in the north by ca. 40,000 years ago. For example, dates for the Aurignacian at El Castillo, in Santander, are as old as any from eastern Europe (Camps and Calbet, 2004). The rest of Iberia, however, shows a persistence of the Middle Paleolithic until at least 30 kya, and possibly as late as 27 kya. The youngest Mousterian assemblages in Portugal date to approximately 28,000 years ago (Raposo, 2000), matching the data for Valencia and Andalucia (Zilhão, 2000).

Despite chronological overlap and geographic proximity, there seems to be little interchange of technology between the Upper and Middle Paleolithic (Straus, 1996; Vaquero and Carbonell, 2000). However, the behavioral nature of the transition itself and the notion that southern Europe served as an Upper Pleistocene Neanderthal refuge remain contentious and poorly understood issues (Finlayson and Pacheco, 2000). Radiometric dating has also been problematic because the transition interval coincides with the limits of the method. On the basis of available dates, the transition along the Mediterranean coast of Spain appears to have progressed in time from north to south across a span of approximately ten thousand years (Bar-Yosef, 2000; Sánchez, 2000; Vaquero and Carbonell, 2000; Villaverde et al., 1998). This is intriguing due to the possible implications for population replacement, but refined chronological work is necessary to fully delineate the late persistence of Middle Paleolithic industries in the south (Sánchez, 2000; Villaverde et al., 1998).

2. Background on Paleolithic land-use studies

Did behavior change in a mosaic fashion, more profoundly, or even at all from the Middle to the Upper Paleolithic in eastern Spain? Behavioral change has traditionally been examined using typological variation of lithic artifacts, but it is equally, if not more, important to understand differences in how foraging societies organized themselves in their landscape. Some have suggested that Middle Paleolithic spatial patterns, at both the intersite and intrasite levels, are monotonous and less complex than those of the Upper Paleolithic (e.g., Vaquero, 1999). Others see evidence in raw material procurement and subsistence strategies for heterogeneity in land-use (e.g., Tuffreau et al., 1997).

Intersite spatial analysis of the Middle to Upper Paleolithic transition has rarely been undertaken (Barton et al., 1999, 2002, 2004; Marks, 1976, 1977, 1983), and a historical emphasis on discrete, site-based survey (Gallant, 1986) has limited our ability to perceive the continuum of behavioral patterns at regional scales. There has been, however, research on the way in which the organization of lithic technology can generate inferences about land-use, notably Barton (1998), Villaverde et al. (1998), and Kuhn (1991, 1992, 1993) in the Mediterranean. Riel-Salvatore and Barton (2004) examined patterns of curation in the Middle and Upper Paleolithic of Italy and Spain and will serve as a comparison to the results presented here.

3. Description of study area and archaeological database

The data used in this study derive from systematic, intensive surveys, conducted since 1989, in eight valleys in eastern Spain, transecting an altitudinal gradient of c. 900 m and covering an area of c. 1800 km^2 (Barton et al., 1999, 2002) (Fig. 1). Artifact distributions from three of these valleys, the Polop Alto, Penaguila, and Alcalá, are the basis for inferences about changing land-use across the Upper Pleistocene

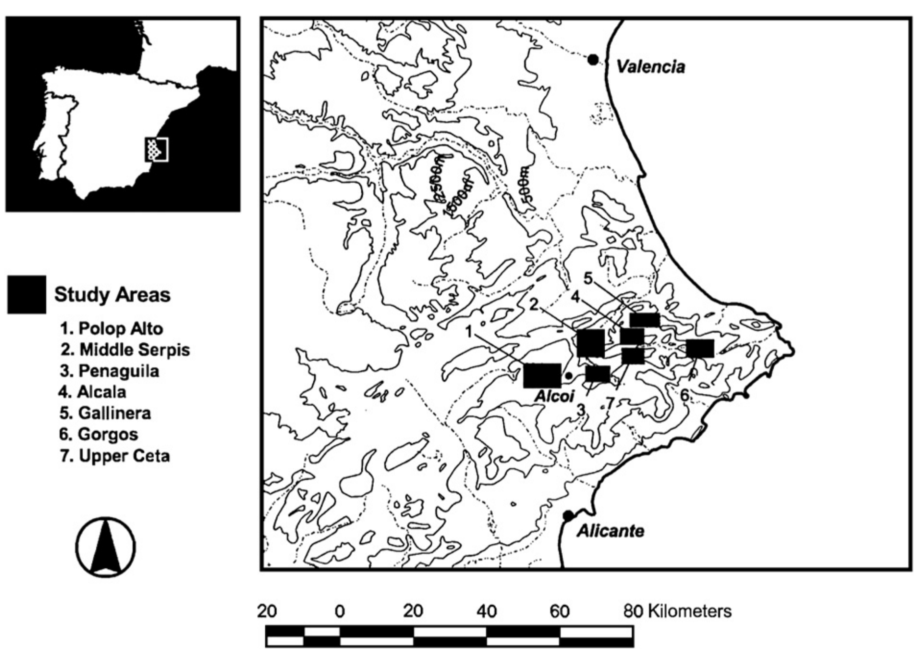

Fig. 1. Location of valleys under survey (Barton et al., 2004).

Middle–Upper Paleolithic transition. These three valleys were selected for analysis because all have Middle and Upper Paleolithic occupation, and produced relatively high artifact densities in comparison with the other valleys surveyed.

A patch-based survey strategy was employed, instead of the more common site-based approach. This methodology focused on recording information on and collecting artifacts from "patches" of land (*sensu* Collins et al., 2000) rather than seeking sites. Small, terraced agricultural fields were used as patches, serving as the basic spatial data collection unit. A multi-stage, stratified, random sampling strategy was used to select patches for data collection. This approach is explained in detail in Barton et al. (1999, 2002) and Bernabeu Auban et al. (1999). All prehistoric artifacts, regardless of size, were collected from sampled patches; concentrations of historic (i.e., post Bronze-Age) artifacts were noted and diagnostic artifacts were collected. The prehistoric artifact collections were dominated by lithics, with 2861, 3791, and 1102 pieces from the Polop Alto, Penaguila, and Alcalá valleys respectively. Additionally, small numbers of ceramics and other prehistoric artifacts (e.g., ground stone, shell) were recovered (Barton et al., 1999, 2002; Bernabeu Auban et al., 1999).

3.1. Post-depositional processes

Extensive analysis of post-depositional processes in the Polop Alto and Penaguila valleys (Barton et al., 1999, 2002; Bernabeu Auban et al., 1999) indicated that sediment movement was minimal in the alluvial fans and benches of the valley margins characterized by well-developed Pleistocene soils. Holocene soils dominate the central part of the valleys, indicating landscapes that have been altered since the Pleistocene.

Erosion, especially recent sheet wash due to cultivation, is the most significant land-altering process. In areas with heavy sheet erosion, few if any artifacts were found. These areas can be detected clearly in high-resolution aerial photographs because the stripping of the red and brown terra rosa soils exposed underlying white marls which were excluded from analysis. Artifacts moved due to erosion appear to have been either reburied or removed altogether from the study area and do not contribute to accumulations elsewhere in the drainages surveyed. Hence, Middle and Upper Paleolithic artifact assemblages have been affected by region-scale landscape formation processes in equivalent ways, making meaningful comparisons possible between these periods.

4. Analysis of geographical variables and lithic assemblages

4.1. Methodology of geographic analysis

Barton et al. (1999, 2002, 2004) developed a new method for making chronological assignments to artifact data gathered through survey. For each collection, a "Temporal Index" (TI) was assigned, based on proportions of diagnostic and artifact types. TI is an estimate of the probability that a patch was occupied during a particular time period, and as such takes values between zero (unlikely) and one (highly likely). These estimates allow each collection unit to be assigned to a set of chronological intervals—the Middle Paleolithic, Upper Paleolithic, late Upper Paleolithic/Mesolithic, Neolithic I, or Neolithic II—with different degrees of probability. The criteria for calculating the TI estimates are well described elsewhere (Barton et al., 1999, 2002, 2004; Bernabeu Auban et al., 1999). These are summarized in Table 1 for all periods, although only the Middle and Upper Paleolithic are considered here.

The "Settlement Intensity Index" (SII) (Barton et al., 1999, 2002, 2004; Bernabeu Auban et al., 1999) is based on the TI and serves as a proxy measure for occupational intensity across the landscape. Assemblages from all survey patches were ranked on the basis of lithic artifact density (pieces/km^2) and assigned values from zero (lowest densities) to one densities). Those values were then multiplied by the TI values of each survey patch for each time period to produce raw SII values. While SII raw values are not comparable between time periods, they can be ranked within a time period (Barton et al., 1999). An ongoing program of excavation has so far confirmed the utility of TI and SII as estimates of prehistoric land-use (Barton et al., 2004; García Puchol et al., 2001, García Puchol et al., in press; Bernabeu Auban et al., 2003).

We used the SII to isolate the most intensively used areas for each valley and time period. Based on previous work done on this project (Barton et al., 2004), we chose two thresholds of occupational intensity to examine: those with SII values at the 75th percentile and above and those at the 90th percentile and above for each time period. The emphasis on high SII value areas is due to issues of equifinality. Areas with low SII values have low artifact density and low TI values; these can be a result of formation processes or visibility and not actual evidence of prehistoric land-use (Barton et al., 2002; Bernabeu Auban et al., 1999). For example, differential visibility of the ground surface, due to plant cover differences had significant effects on artifact recovery for patches with low artifact densities, but not for patches with higher density. Hence, we focus here on survey patches with relatively high values for TI and SII in each valley as the foundation for the subsequent analysis.

Land-use among hunter-gatherers generally follows floral and faunal resource availability, which may be influenced by altitude, slope, and orientation (Pickering, 2003). As has been shown by many studies, these variables are important to humans in settlement decisions (Cashdan, 1983) and thus have considerable utility for predicting site location (Altschul, 1990; Dalla Bona, 2000; Furlong, 1917; Kohler and Parker, 1986; Schuldenrein and Clark, 2001, 2003). While land-use decisions clearly incorporated more than these three variables (Church et al., 2000), these still account for substantial topographical variation and are used here to analyze variation in the locations of artifact concentrations for the Middle and Upper Paleolithic.

Table 1
Criteria for defining TI values (from Barton et al., 1999)

Period	TI: 0.9	TI: 0.7	TI: 0.5	TI: 0.3[i,j]
Late Neolithic	Late Neol. tools[a] or late Neol. ceramics	Ceramics or ground stone. Absent: backed tools and early Neol. tools[d]	Neol. tools,[b] ceramics or ground stone	Blade tech.[c]
Early Neolithic	(Backed tools and (ceramics or early Neol. tools)) or early Neol. ceramics. Absent: late Neol. tools and late Neol. ceramics	Neol. tools, ceramics or ground stone. Absent: late Neol. tools and late Neol. ceramics	Backed tools or ceramics	Blade tech.
Late Upper Paleolithic and Epipaleolithic	Backed tools. Absent: Neol. tools and ceramics	Backed tools.[e] Absent: ceramic density <75/km^2	Backed tools or blade tech. Absent: ceramic density <75/km^2	Backed tools or blade tech.
Upper Paleolithic	U. Paleo tools[f] and blade tech. Absent: backed tools, Neol. tools and ceramics	U. Paleo tools or blade tech. Absent: backed tools, Neol. tools and ceramics	U. Paleo tools or blade tech. Absent: ceramic density <75/km^2	U. Paleo tools or blade tech.
Middle Paleolithic	M. Paleo tools.[g] Absent: U. Paleo tools, backed tools, Neol. tools, blade tech. and ceramics	M. Paleo tools. Absent: backed tools, Neol. tools, and ceramics	M. Paleo tools. Absent: ceramic density >75/km^2	M. Paleo tools or flake tech.[h]

[a] Late Neolithic lithic tools include bifacial projectile points and denticulated sickle blades. The latter also occur in Bronze Age contexts, but are only found in association with other Neolithic artifacts in our collections from the Polop Alto; hence they are used here as a marker for the Late Neolithic.
[b] Neolithic tools (Early and Late) include plain (i.e., undenticulated) sickle blades and bifacial drills (taladros).
[c] Besides prismatic blades, evidence for blade technology includes crest blades, blade cores, and blade core face and platform rejuvination flakes.
[d] Early Neolithic tools are finely retouched (utilized) bladelets. Backed tools include backed bladelets, backed points, and geometric microliths.
[e] This is an empirical figure for "background" ceramics derived from examining density histograms of ceramics for the entire Polop Alto survey area.
[f] Upper Paleolithic tools include endscrapers, burins, truncations, and perforators.
[g] Middle Paleolithic tools include sidescrapers (including transverse and déjéte scrapers), notch/denticulates, and Mousterian points.
[h] Flake technology includes flakes and flake cores—both prepared (e.g., discoid and levallois) and amorphous.
[i] For each period, a TI value of 0.1 is known by a presence of artifacts (lithics only for the Middle Paleolithic, Upper Paleolithic, and late Upper Paleolithic/Epipaleolithic.
[j] For each period, a TI value of 0 is known by an absence of artifacts.

A digital elevation map, at 25 m resolution, was used to model elevation. From this map, slope and aspect maps were generated in GRASS GIS (Grass Development Team, 2006). Aspect refers to the direction a slope is facing and varies from 0 to 360 degrees from east and was calculated only for areas with slope greater than 10 degrees. At low slopes, aspect cannot be reliably determined and is probably not meaningful in land-use decisions. Slope and aspect values were binned in five degree intervals in order to smooth variation. Using the r.statistics module in GRASS (Grass Development Team, 2006), elevation, aspect, and slope interval was calculated for all survey patches with high SII values for the Middle and Upper Paleolithic.

A Wilcoxon matched pairs comparison was employed to assess the variation in occupation with regards to elevation, aspect, and slope for the three valleys. Wilcoxon matched pairs tests determine whether or not two samples derive from the same population. The two-tail probability, p, is defined as the probability of the differences occurring by chance (Gaten, 2000). For this analysis, a p value of 0.1 was considered significant (see Cowgill (1977) for a discussion of appropriate significance levels in archaeology). Each distribution (total survey area, MP with SII over 75th percentile, UP with SII over 90th percentile, etc) was tested against every other distribution within a valley.

Aspect data proved problematic. Once low slope areas were removed from analysis, little remained on which to measure aspect, particularly in the Alcalá valley. As a result, the distributions for each valley and time period included many zero values. As a solution, only presence/absence data, rather than SII values, for each aspect interval were used. Wilcoxon matched pairs tests were then conducted on the transformed presence/absence data.

4.2. Results of geographic analysis

4.2.1. Elevation

An example of the elevation distributions for the time periods and intensity levels of interest in the Penaguila valley is shown in Fig. 2. Mean elevations for Paleolithic assemblages are generally higher than the means for total surveyed area. This is not surprising, given that Pleistocene surfaces are best preserved and exposed along the higher elevation valley margins; in lower elevation central valley areas, they are often buried by Holocene sediments. Exceptions include the Middle Paleolithic in the Alcalá valley, along with Middle Paleolithic with SII in the ≥75th percentile and Upper Paleolithic with SII in the ≥90th percentile in the Polop Alto valley.

The results of the statistical comparison of Middle and Upper Paleolithic land-use by elevation are given in Table 2. According to the Wilcoxon test, the differences between the Middle and Upper Paleolithic areas utilized at corresponding intensity levels have a high probability of being due to chance. The only exception is the Penaguila valley; in this situation the differences between time periods are significant. However, both time periods are significantly different from the total surveyed area ($p \leq 0.1$) (Table 2).

4.2.2. Slope

Wilcoxon test results on slope distributions are given in Table 2. Again, both time periods vary from the total surveyed

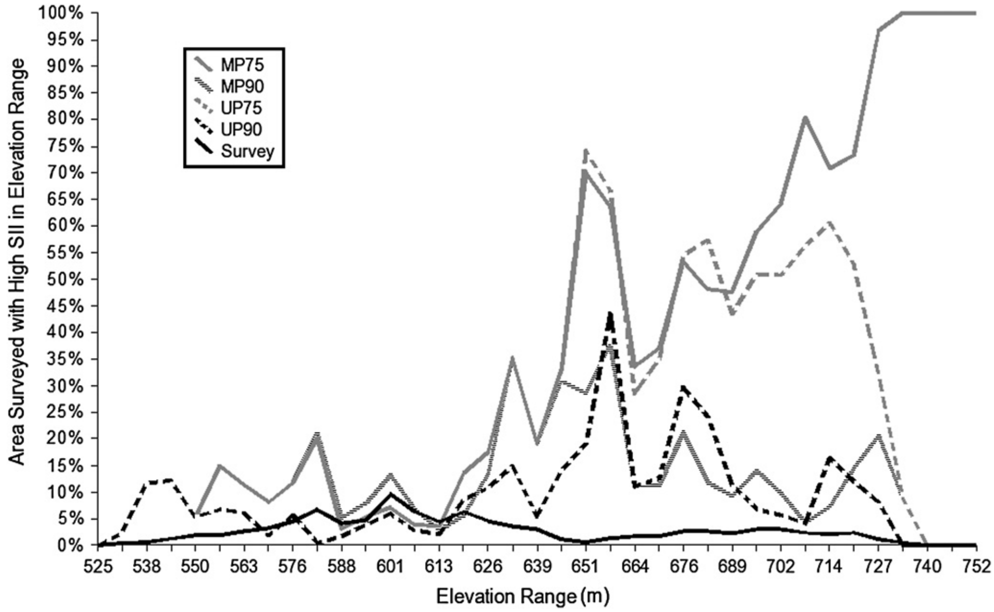

Fig. 2. Elevation distribution per time period and settlement intensity level for Penaguila valley.

area; Paleolithic assemblages are typically found on steeper slopes than those characteristic of the surveyed area as a whole (see Fig. 3 for the example of the Penaguila valley) with $p \leq 0.1$. Like elevation, this may well be a result of landscape formation processes. In the Polop Alto, the pattern follows that of elevation; there are no significant differences between time periods. Again intensely occupied areas ($\geq$90th percentile) and moderately occupied areas ($\geq$75th percentile) differ statistically in the Middle Paleolithic, but the Upper Paleolithic does not show similar differences. The overall preference for steeper slopes when compared to those found generally in the survey area, is unexpected, but it may relate to elevation patterns.

In the Penaguila valley, all comparisons are significantly different ($p \leq 0.1$). Each time period and settlement intensity level is distributed differently in terms of slope. The high intensity occupations tend to occur on steeper slopes than the other areas used. Both Middle and Upper Paleolithic areas are proportionally higher in slope than the mean of the surveyed area. The Penaguila pattern of variation contrasts sharply with that of the Alcalá valley. In the Alcalá, neither differences between the Middle and Upper Paleolithic, nor variation within time periods, are significant.

4.2.3. Aspect

The results of Wilcoxon tests on occupation distribution in relation to aspect are given in Table 2. Polar graphs, with scales corresponding to degrees from east, are given in Figs. 4 and 5. The Penaguila and Polop Alto valleys display very low p values across all combinations. The only difference that is not statistically significant is between moderately occupied areas ($\geq$75th percentile) for the Middle and Upper Paleolithic. However, the probability of these samples deriving from the same population is still low in the Penaguila ($p = 0.0577$). The p values show little consistent pattern in the Alcalá valley. However, the amount of land in the Alcalá valley with a slope sufficient for aspect analysis is small, and thus sample size is likely affecting the outcome of analysis.

The patterns of aspect distribution are generally similar despite their statistical differences. However, some differences stand out. In the Polop Alto valley, there is a lack of occupation in areas facing northwest, and the Upper Paleolithic shows a preference towards southwest facing areas. In the Penaguila valley, facing south appears to be avoided generally, and Middle Paleolithic occupations are on land surfaces inclined towards the north or northeast. The meaning of the variation within and between valleys is unknown, but some possible factors influencing aspect of occupation include sunlight direction and faunal migratory patterns.

4.2.4. Lithic analysis

Stone tools are the primary data available from the Paleolithic. Examining morphological variability in lithic assemblages can be informative for understanding settlement systems, mobility, and raw material procurement (Barton, 1990; Kuhn, 1992; Marks, 1976, 1977, 1983; Shott, 1996). While the earlier examination of use of different aspects of landforms informs about the location of occupation, lithics can highlight the nature of those occupations. These are inherently connected elements of land-use. ‘‘Technological organization is responsive to conditions of the environment including resource predictability, distribution, periodicity, productivity, and mobility’’ (Nelson, 1991). Curation patterns and mobility strategies can be inferred from artifact attributes, and these inferences can contribute to understanding why occupation occurred in certain areas and not others, and why certain sites were occupied for greater or lesser amounts of time (Nelson, 1991; Potter, 1993).

Table 2
Wilcoxon signed ranks test results (all two-sided probabilities using normal approximation)

			MP75	MP90	UP75	UP90	SURVEY
Elevation	Alcala	MP75	1.000				
		MP90	0.008	1.000			
		UP75	0.328	0.010	1.000		
		UP90	0.083	0.594	0.005	1.000	
		Survey	0.003	0.003	0.003	0.003	1.000
	Penaguila	MP75	1.000				
		MP90	0.000	1.000			
		UP75	0.013	0.002	1.000		
		UP90	0.000	0.015	0.000	1.000	
		Survey	0.000	0.000	0.000	0.000	1.000
	Polop Alto	MP75	1.000				
		MP90	0.000	1.000			
		UP75	0.620	0.000	1.000		
		UP90	0.000	0.476	0.000	1.000	
		Survey	0.000	0.000	0.000	0.000	1.000
Slope	Alcala	MP75	1.000				
		MP90	0.109	1.000			
		UP75	0.068	0.068	1.000		
		UP90	0.285	0.593	0.068	1.000	
		Survey	0.068	0.068	0.068	0.068	1.000
	Penaguila	MP75	1.000				
		MP90	0.028	1.000			
		UP75	0.043	0.075	1.000		
		UP90	0.018	0.018	0.018	1.000	
		Survey	0.008	0.008	0.008	0.008	1.000
	Polop Alto	MP75	1.000				
		MP90	0.043	1.000			
		UP75	0.463	0.028	1.000		
		UP90	0.046	0.917	0.109	1.000	
		Survey	0.028	0.028	0.028	0.028	1.000
Aspect	Alcala	MP75	1.000				
		MP90	0.317	1.000			
		UP75	0.008	0.005	1.000		
		UP90	1.000	0.317	0.008	1.000	
		Survey	0.000	0.000	0.000	0.000	1.000
	Penaguila	MP75	1.000				
		MP90	0.000	1.000			
		UP75	0.058	0.000	1.000		
		UP90	0.000	0.000	0.000	1.000	
		Survey	0.000	0.000	0.000	0.000	1.000
	Polop Alto	MP75	1.000				
		MP90	0.000	1.000			
		UP75	0.622	0.000	1.000		
		UP90	0.020	0.001	0.002	1.000	
		Survey	0.000	0.000	0.000	0.000	1.000

MP75 = areas with SII values in the 75th or higher percentile for the Middle Paleolithic; MP90 = areas with SII values in the 90th or higher percentile for the Middle Paleolithic; UP75 = areas with SII values in the 75th or higher percentile for the Upper Paleolithic; UP90 = areas with SII values in the 90th or higher percentile for the Upper Paleolithic.

Curated artifacts are those manufactured in anticipation of future needs and discarded toward the end of their potential use-life (Bamforth, 1986; Nelson, 1991; Shott, 1996). Curated tools are generally portable and can be reworked, should the need to do so arise. This strategy is advantageous for highly mobile people who need a high ratio of cutting edge relative to weight (Kuhn, 1992). Curation conserves raw material through tool maintenance and recycling (Bamforth, 1986). More eloquently, Shott argues that curation can be scaled according to ‘‘the degree of use or utility extracted, expressed as a relationship between how much utility a tool starts with – its maximum utility – and how much of that utility is realized before discard’’ (Shott, 1996). The idea of curation is similar to that of ‘‘provisioning individuals’’ (Kuhn, 1992) and is optimal for mobile people, especially under conditions of local raw material scarcity (Bamforth, 1986; Kuhn, 1992). Artifacts with significant amount of retouch are considered to be indicative of curation.

Expedient tools are those produced for a task at hand. They are typically discarded before their utility is expended (Nelson, 1991). Expediency is essentially the inverse of curation, but has become a term in its own right in archaeological literature (Shott, 1996). Expedient behavior assumes the presence of suitable raw material nearby and the time to manufacture tools. Availability of raw materials can be either at sources or created by raw material stockpiling (Nelson, 1991). A dominance of lithic artifacts with little or no retouch are taken to represent expediency. Curation and expediency are ends of a continuum and most assemblages contain lithics that were curated or created expediently (Potter, 1993).

Mobility refers here to the frequency of movement across a landscape and correspondingly to the time spent in any residential site. Mobility, or the relative lack thereof, influences the morphology and use of lithic tools. The connection between curation and mobility was originally made by Binford (1973) and Marks (1976, 1977, 1983), and subsequently has been generalized and expanded by many authors (Bamforth and Becker, 2000; Nelson, 1991; Parry and Kelly, 1987; Shott, 1996). When people are highly mobile, they typically know less about the immediate landscape than those who occupy it persistently; there is less opportunity to locate and procure raw material and materials must be reused (see also Potter, 1993). There is also a need for a high degree of portability in material culture. These factors encourage the curation of essential lithic artifacts. On the other hand, longer residential stays at a locale reduce the need for portability and increase the potential to stockpile raw material, both of which encourage expedient lithic use.

In order to examine patterns of curation for the Polop Alto, Penaguila, and Alcalá valleys, a method proposed by Riel-Salvatore and Barton was employed (Barton, 1998; Riel-Salvatore and Barton, 2004). As originally designed, it compared artifact volumetric density against relative frequency of retouched pieces within assemblages. Artifact volumetric density is the total number of chipped stone artifacts per cubic meter of sediment. Assemblages with a high frequency of retouch relative to volume are considered to be indicative of curation. This method has the advantage that comparisons can be made across temporal and spatial boundaries (Riel-Salvatore and Barton, 2004).

Riel-Salvatore and Barton's results from various sites in Spain and Italy indicate a strong inverse relationship between artifact density and relative frequency of retouched pieces. Assemblages that display high frequency of retouched tools with low artifact density are indicative of an emphasis on curation. Assemblages with low frequencies of retouched tools and high

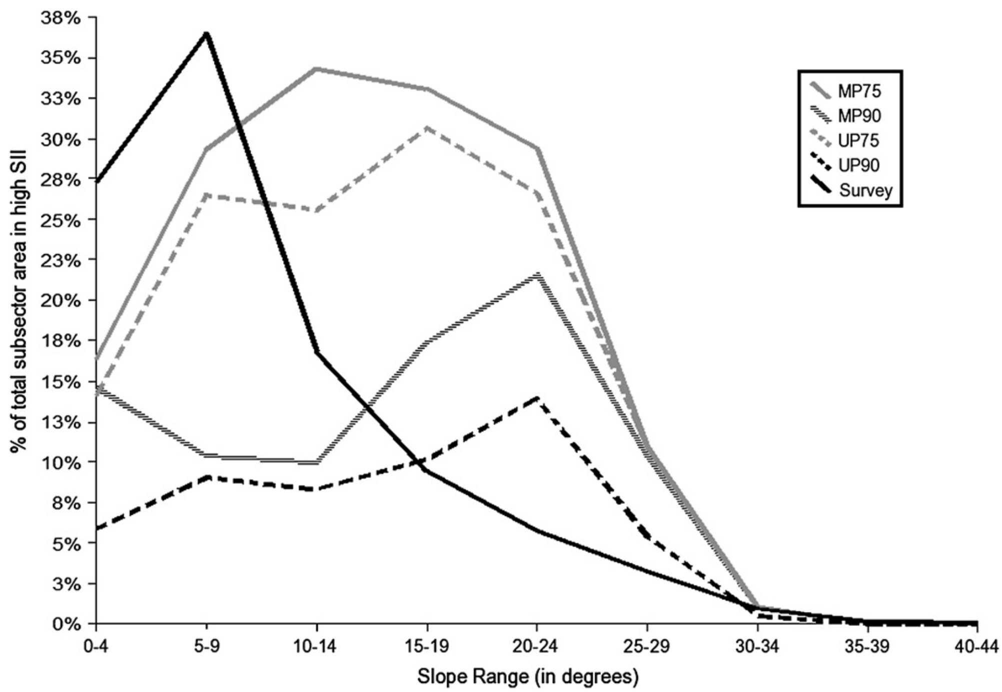

Fig. 3. Slope distribution per time period and settlement intensity level for Penaguila valley.

artifact density indicate expediency. Curation, which conserves raw material, and expediency, which 'wastes' it, relate to effective lithic abundance and mobility (Bamforth and Becker, 2000; Barton, 1998; Nelson, 1991; Parry and Kelly, 1987; Riel-Salvatore and Barton, 2004; Shott, 1996). Expedient assemblages can indicate the locations of central camps or locations near raw material sources, while curated assemblages can indicate short term occupations either in the form

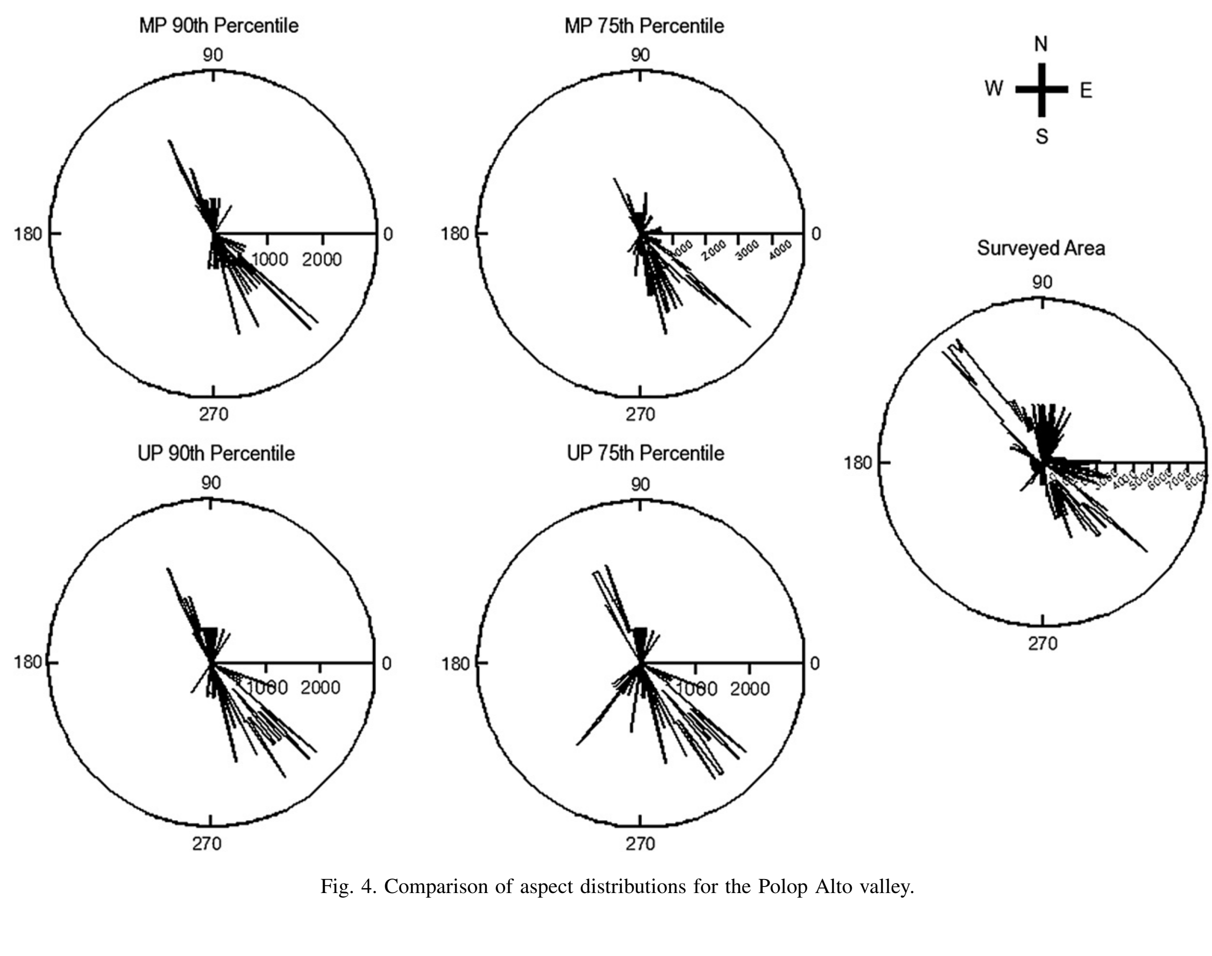

Fig. 4. Comparison of aspect distributions for the Polop Alto valley.

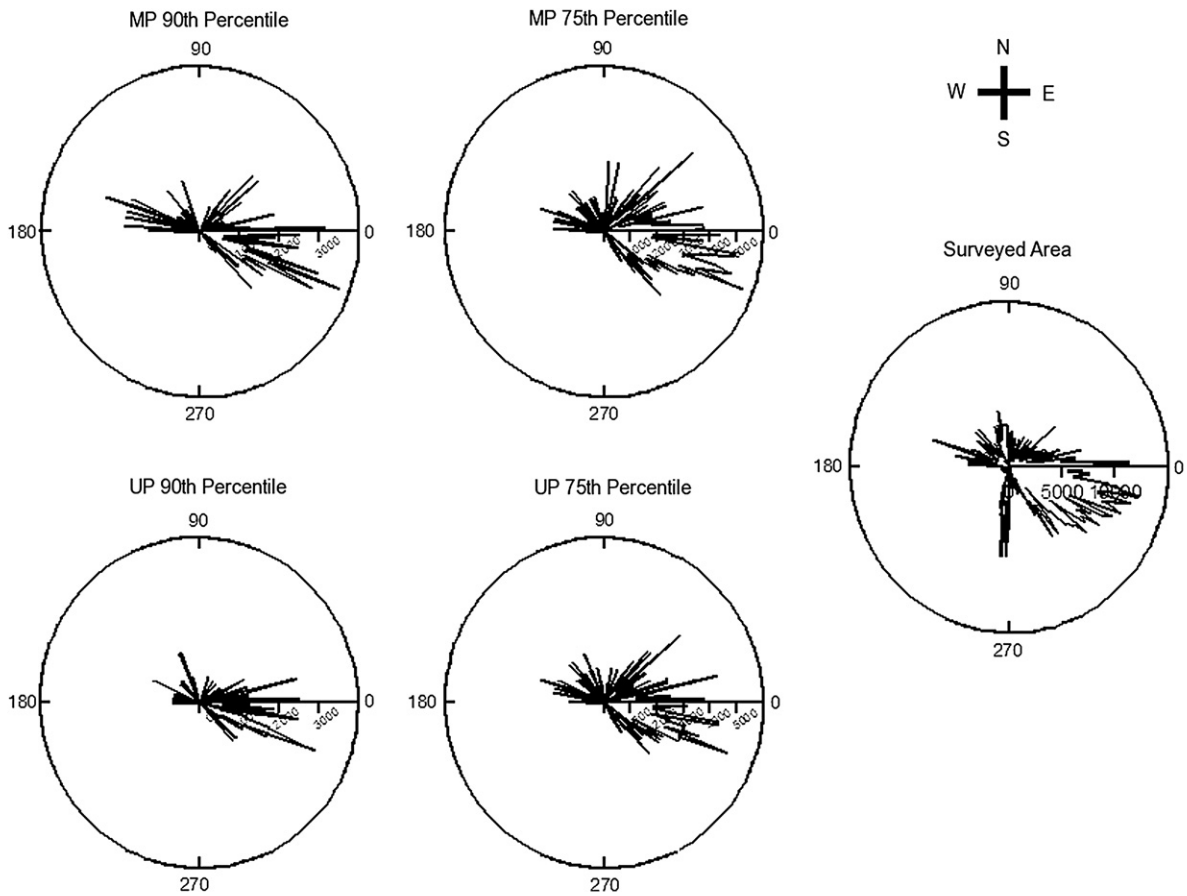

Fig. 5. Comparison of aspect distributions for the Penaguila valley.

of shifting residential bases or expeditions from logistical base camps (Riel-Salvatore and Barton, 2004).

Because this analysis is based on survey data, surface area of survey units was calculated instead of volume. To generate a figure approximating a total artifact count per time period, the total count of all lithics per survey patch was multiplied by the corresponding TI values per time period. This value was divided by survey unit area to approximate lithic density. Curated ''tool'' counts per period included only ''tools'' as defined by Bordes' (1961) and de Sonneville-Bordes and Perrot's (1954, 1955, 1956) typologies; this omits retouched pieces without formal types. While the authors do not agree with this separation, it was necessary as non-retouched pieces can not be reliably divided into time period.

Relative frequency of tools plotted against artifact density for the surveyed valleys produces patterns that generally match the correlations seen in the Riel-Salvatore and Barton (2004) analysis, which emphasized stratified cave sites. The Middle Paleolithic of the Polop Alto has a low correlation value but follows the predicted trend. The Alcalá valley is unusual with a high incidence of zero values for retouch frequency that are not apparent on the logarithmic scaled graph. This high frequency of unretouched pieces implies a high degree of expediency. However, some patterns emerge.

The degree to which the tool frequency/artifact density relations conform to the predicted pattern suggests that tool frequency alone can serve as a proxy measure of mobility. This permits comparisons across the Middle–Upper Paleolithic transition in the valleys analyzed. This is shown in Fig. 6. Artifacts from the Polop Alto appear to be more heavily curated than those in the Penaguila, especially during the Middle Paleolithic. The Polop Alto exhibits a difference between the Middle and Upper Paleolithic with the former more heavily curated than the latter. This distinction is stronger than the differences between the Middle and Upper Paleolithic in the Penaguila or Alcalá valleys. However, the variation between the box-plots is not large overall.

These results can be compared to the work of Kuhn in the Mediterranean. Along with American and Italian colleagues, he compared lithic assemblages from multiple cave and rockshelter sites along the Latium coast in Italy. Three sites were associated with the Mousterian and one was associated with the Epigravettian. After controlling for raw material availability, Kuhn determined that the Mousterian lithics were more intensively utilized and reduced than those of the Upper Paleolithic (Kuhn, 1991, 1992, 1993). This contrasts with the findings reported above. These differences may be due to raw material availability or the inherent differences between excavation and survey data. Differential sampling of coastal versus interior sites may also contribute. These issues need to be addressed before further comparison can be completed.

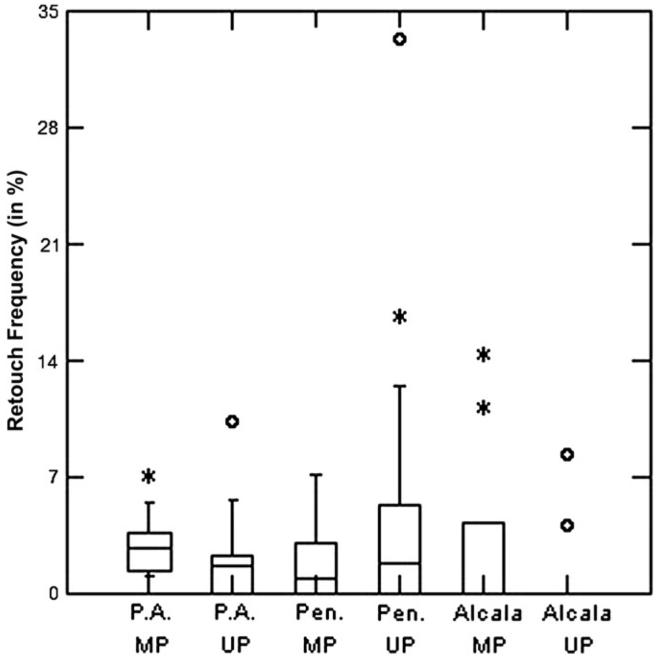

Fig. 6. Box plots comparing retouch frequency across time periods in the Polop Alto, Penaguila, and Alcala valleys.

5. Discussion

General patterns emerge from the analyses described above, but these vary by valley. In the Penaguila valley, both time periods, as well as occupation intensity levels, differ significantly from one another. This holds true for elevation, slope, and aspect. From the Middle to Upper Paleolithic, individuals rearranged the way in which they positioned themselves on the land.

In the other valleys, land-use patterns are more stable through time. In the Alcalá and Polop Alto valleys, the mean elevations of areas with more and less intense occupation are different but do not change in a meaningful way over time. Elevation ranges occupied most intensely also differ from those under moderate occupation intensity. However, there are no significant differences in landforms occupied between the Middle and Upper Paleolithic periods in either valley. The variation between occupation intensities does not appear to be related to absolute elevation ranges of the valleys studied, however, given the overlap in elevation between the Alcalá and Penaguila valleys. For the Polop Alto and Alcalá valleys, the pattern for slope is similar to that for elevation. It differs between occupation intensity levels for both time periods, but there is no significant difference in the slope of occupied land between the Middle and Upper Paleolithic except for patches at the $\geq$ 75th percentile SII areas in the Alcalá valley. The results are more ambiguous for aspect. For the Polop Alto valley, all differences are significant except for that between the $\geq$ 75th percentile SII areas in the Middle and Upper Paleolithic. In the Alcalá valley, most differences are significant. However, there is no statistical difference between the $\geq$ 90th percentile SII areas of the Middle and Upper Paleolithic, nor are there differences between the various occupation intensity levels in the Middle Paleolithic.

The nature of variation in the geographic variables differs by valley, but the only apparent general trend is towards more intense use of higher slopes during both time periods. The specific differences between the Middle and Upper Paleolithic, as well as those between occupational intensity levels, vary by valley, but all show a preference towards steeper slopes. However, as previously noted, this may well be an artifact of Holocene erosion filling valley bottoms and burying evidence of a Paleolithic presence. For all geographic variables, there are significant differences for all time periods between the distribution of occupation and the surveyed areas. However, the pattern of occupation does not vary in any consistent way between the Middle and Upper Paleolithic. The data employed here, and especially their characterization for quantitative analysis (i.e., TI and SII values), are highly abstracted and their resolution is coarse. Given the palimpsest nature of surface assemblages, the significant span of time examined, and the high degree of time-averaging common in most Paleolithic contexts, this abstraction is unavoidable. Nonetheless, apparently meaningful variation does appear in these land-use indices, as noted here and elsewhere (e.g., Barton et al., 2004), but not in terms of differences between the Middle and Upper Paleolithic.

The same lack of clear-cut differences in between the Middle and Upper Paleolithic can be seen in the results of the lithic analysis. While the trends are subtle, there appears to be a slightly higher level of artifact curation overall in the Polop Alto than in the Penaguila valley. Within the Polop Alto valley, curation is more prevalent in the Middle Paleolithic than in the Upper Paleolithic, possibly indicating reduced mobility in the Upper Paleolithic. In the other valleys, no notable difference between time periods is evident, suggesting that the same range of mobility strategies were in the Middle and Upper Paleolithic, producing closely similar time-averaged lithic accumulations.

6. Conclusion

This study demonstrates that, at least as far back as the early Upper Pleistocene, foragers in Valencia were using landforms with specific characteristics. In all the valleys and across all physical variables considered here, there is a difference between the areas occupied with moderate intensity and those with greater intensity. In other words, locales combining acceptable ranges of elevation, slope, and aspect, were used repeatedly throughout the Upper Pleistocene by forager groups. It is possible that when these areas were occupied at carrying capacity or otherwise unavailable, foragers expanded their definition of acceptable habitat to include resource patches previously ignored, or exploited with less intensity.

There is not, however, a consistent difference between Middle and Upper Paleolithic use of the landscape. In the Penaguila, the areas occupied during the Middle Paleolithic were different in elevation, slope, and aspects from those occupied during the Upper Paleolithic. The reason for this shift in habitat preference is unclear, but may be related to shifts in resource distributions caused by climatic change from the late Middle to Upper Pleistocene. However, in the nearby Polop Alto and Alcalá valleys, elevation and slope ranges were essentially the same during the Middle and Upper Paleolithic. Either elevation and slope were not important factors in land-use decisions for early hunter-gatherers or there were natural constraints preventing individuals from occupying ideal areas. However, in the Polop Alto and Alcalá valleys, aspect varies between time periods. During the Middle Paleolithic, more of the occupied areas were facing south-east but in the Upper Paleolithic they were also facing north-west as well as south-west.

No significant difference in curation levels between the valleys or between time periods was observed. However, the Polop Alto Middle Paleolithic assemblage does show stronger evidence of more intense curation than the other valleys and time periods. Low effective abundance of raw material in that particular drainage may have necessitated re-use and recycling of stone tools. Future research into availability of raw material will facilitate the interpretation of this pattern.

Because consistent variation in the use of land forms between the Middle and Upper Paleolithic occupations could not be demonstrated, land form use alone can not be used a marker of behavioral modernity or the onset of the Upper Paleolithic in general in this region. The series of warm and cold intervals that occurred over the time range of this study, may better explain variation, but it is currently impossible to demonstrate this with temporally-coarse survey data.

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