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Water availability and landuse during the Upper and Epipaleolithic in southwestern Syria

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ABSTRACT

Paleolithic research often assumes that environmental conditions played a major role in shaping human evolution. To study this relationship we present a spatially explicit approach based on the assumption that the distribution of water within the landscape is an essential component of local environmental conditions. Here, we analyze the relation of wetness and human landuse patterns from the Upper Paleolithic (UP) and Epipaleolithic (EP) of Western Syria. In particular the spatially explicit character of the approach enables the detection of a significant change in landuse patterns during the UP and EP accompanied by a significant shift in the wetness characteristics of the preferentially used areas. These results are discussed against the background of published data on climatic conditions in order to identify both a possible time frame and triggers for this change in landuse. While we conclude an increased influence of natural conditions on the spatial behavior for the UP, we suggest an additional influence of cultural circumstances in shaping EP spatial behavior. For the region studied we argue that the bounded pattern observed during the UP changes to a spatially flexible pattern during the Late Natufian.

1. Introduction

Paleolithic research often places a high level of importance on the environment's role in determining Paleolithic populations' evolutionary and cultural development (Banks et al., 2008; Binford, 2001; Collard and Foley, 2002; Foley, 1995). A variety of studies has been published using a broad range of approaches. The most common approach analyzes archaeological site distributions with respect to environmental variability (Bretzke, 2008; d'Errico and Sanchez-Goni, 2003; Gamble et al., 2004). In addition, archaeologists increasingly realize the potential of GIS based models for studying the relationship between humans and their inhabited environment (Banks et al., 2008, 2006; Burke et al., 2008). Regardless of the approach chosen, one shortcoming is the disagreement between the spatial resolution of the archaeological and climatic data. While archaeological finds can be located precisely using GPS or high resolution maps, paleo-environmental information taken from climate proxies or climatic simulations usually considers average developments over large areas and therefore yields low spatial resolution. Hence, available climatic data often underestimates local variation, a factor which is particularly important for the distribution of vegetation that forms the basis for animal and human life. Especially in arid regions, the vegetation pattern is closely bound to the availability of water. Therefore, knowledge about the local distribution of water in the landscape is a critical prerequisite for the assessment of human–environment interactions.

Here, we describe a method that transforms low resolution precipitation data into high resolution surface-wetness distribution data at a regional scale. We assume water availability as a critical factor shaping the spatial distribution of plants and animals, and therefore human biotic resources. Then we compare the wetness distribution with landuse patterns from the Upper Paleolithic (UP) and Epipaleolithic (EP) of Western Syria to characterize the relationship between human activities and the wetness pattern in the landscape as an indicator of the environment's role in the organization of human spatial behavior.

2. Materials and methods

2.1. Modeling the spatial distribution of wetness

The availability of surface and subsurface water at a specific point in the landscape is primarily a function of the amount and distribution of precipitation and local topography. Information

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about the amount and distribution of precipitation can be either obtained from isohyet maps or calculated from climatic station data. The most complete information about local topography exists as digital elevation models (DEMs). The spatially continuous information of DEMs about topography can be used to determine the amount of water that potentially flows together at any given point in a landscape.

This concept is realized in the ‘Topographic Wetness Index’ (TWI), a well-established secondary topographic attribute introduced by Beven and Kirkby (1979). It assumes that topography controls the movement of water in sloped terrain and hence, the spatial pattern of soil moisture (Schmidt and Persson, 2003). As a consequence, TWI also accounts for water available on the surface. While high TWI corresponds to low lying areas, low TWI values occur in steep, diverging areas.

The TWI applies likewise for subsurface water movements driven by terrain gradient (Barling et al., 1994; Sørensen et al., 2005). One of the characteristics of arid and semi-arid regions is that most precipitation does not infiltrate the sedimentary column where it falls, but drains toward lower areas, even where the surface inclination is slight (Schulz, 2000). The greatest concentration of water can be found in the flat areas between hills where sediments and water collect. With these characteristics, the TWI can be used to differentiate potentially moister areas with higher herbal biomass from drier areas with less vegetation. The major drawback for the application of the TWI with respect to the distribution of surface water is the assumption of a homogenous spatial precipitation pattern over the entire region of analysis. While this assumption is valid for some regions of the world, other regions show variable precipitation patterns on a regional scale dependent upon topographic features. To overcome this weakness, we add the spatial variability of precipitation. We achieved this by multiplying a separate data layer containing information about the spatial distribution of precipitation. The resulting formula defines Plant Available Water (PAW) in a specific region:

$$\mathrm{PAW} = \mathrm{TWI}*\ln(\mathrm{PREC}_{\mathrm{present}}) \tag{1}$$

where $\mathrm{PREC}_{\mathrm{present}}$ represents the present precipitation. The consideration of a spatially explicit precipitation pattern produces a more realistic picture of the distribution of moisture in the landscape than the TWI alone.

2.2. Modeling past human landuse

Since we see the most direct interaction of humans with their environment in the context of gathering and collecting, we consider human activities away from the main living sites. But how can we gain information from this area? One possibility we have explored over the past years (Bretzke, 2008; Bretzke et al., 2011; Conard et al., 2010) necessitates a new way of viewing cultural remains in the landscape. If we change our perspective from identifying sites to the distribution patterns of single artifacts, we access data on human spatial activities across the entire landscape (Dunnell and Dancey, 1983). Our investigations follow an off-site approach, as introduced by Isaac (1981) and Foley (1981), and assume that the accumulation of cultural remains in the landscape is a function of the intensity of its use. Therefore, areas with high artifact densities denote intensively used areas, while low artifact densities indicate locales exploited to a lesser degree. This leads us to conclude that by discerning the spatial distribution of artifact densities, we can posit inferences regarding past human behavior in particular settlement spaces.

Information about the patterning of artifacts in the landscape derives from archaeological survey data. The systematic collection of artifacts and the estimation of artifact densities specific of cultures at all surveyed localities provide a dataset suitable for this analysis. Applying the “Inverse Distance Weighted” interpolation technique (Conolly and Lake, 2006), the density information of artifacts gained from spatially separated localities can be transferred into a spatially continuous dataset that better represents the activity distribution (Bretzke, 2008).

2.3. Case study

We apply this approach to archaeological data from the Tübingen-Damascus Excavation and Survey Project (TDASP in German) (Conard, 2006). The TDASP study area in the Damascus Province about 50 km northwest of Damascus (Syria) is situated between the Anti-Lebanon Mountain range and the Syrian Desert. An impressive cliff line formed of resistant Oligocene limestone represents the border between areas of higher elevation, up to 2300 m, and lowland areas down to 800 m (Fig. 1). The study area is further characterized by a steep gradient in precipitation. While substantial precipitation falls along the western faces of the Anti-Lebanon Mountains, precipitation decreases markedly toward the eastern flanks and the hinterland. Enzel et al. (2008) argue that this overall pattern has not changed considerably since the last glacial/interglacial period. Thus, we can use the present precipitation pattern to create a simplified model of local environmental conditions. The dataset on the spatial distribution pattern of present precipitation in the study area was created by a thin-plate spline interpolation of isohyets from a Syrian precipitation map (Syrian Arab Republic, 1977). Finally, data on the topography derives from a conveniently processed DEM that was based on maps from the shuttle radar topography mission (United States Geological Survey, 2007) (Fig. 2).

The TDASP study region is a highly differentiated landscape with characteristics that likely encouraged Paleolithic settlement in the region. Lithic raw material of good quality is readily available from primary and secondary deposits in many areas of the study region (Dodonov et al., 2007). Another advantageous characteristic is the occurrence of perennial water sources along the cliff line. Today active artesian springs can be found near the base of the cliff line in vicinity to the modern villages of Ma’aloula, Jaba’deen and Yabroud (Fig. 1). These springs are associated with deeply incised canyons, which not only confirm the existence of water sources at these locations for long periods, but also provided easy passage for people and animals between the lowlands and the highlands.

The field work of TDASP builds on previous work in the Damascus Province by Rust (1950), Suzuki and Kobori (1970), Solecki and Solecki (1987/1988), and Bakdach (2000). Before TDASP began working in the Damascus Province, the only stratified Paleolithic assemblages known were those from the sites of Yabrud (Rust, 1950; Solecki and Solecki, 1966). During 12 years of research in the Damascus Province, TDASP conducted excavations in Baaz Rockshelter, a multi-period site with layers from early and late UP and Late Natufian (Conard, 2000; Conard et al., 2006a,b; Deckers et al., 2009), Kaus Kozah Cave, a site containing Middle and Epipaleolithic artifacts (Conard and Masri, 2006), Ain Dabbour, a site with two Geometric Kebaran layers (Hillgruber, 2010), and Wadi Mushkuna, a Middle Paleolithic site currently under excavation (Fig. 1).

Since 1999 TDASP has conducted intensive surveys in the Damascus Province that represent a significant record of Paleolithic data in Southwestern Asia (Conard, 2006). Today, the collection contains chipped stone artifacts from 598 areas (Fig. 3). The record includes all major periods from the Lower Paleolithic to the Neolithic (Table 1). Within our survey area of ca. 500 km^2, we collected artifacts using pedestrian transects through defined areas