ARTICLES

DAILY PRACTICE AND THE ORGANIZATION OF SPACE AT THE DAWN OF AGRICULTURE: A CASE STUDY FROM THE NEAR EAST

Ian Kuijt and Nathan Goodale

Drawing upon the lithic remains from the Late Natufian and Pre-Pottery Neolithic A occupations of 'Iraq ed-Dubb, Jordan, we utilize a quantifiable statistical approach with Geographic Information Systems analysis to interpret shifting practices that influenced site structure. This study indicates that the highly mobile Late Natufian population who inhabited the site had fairly nondelineated use of space compared to a more delineated use of space during the Pre-Pottery Neolithic A. It appears that intensified intra-community organization of space was a byproduct of decreased residential mobility. Moreover, the emergence of more formal intra-community organization likely aided in the development of much more complex human societies that evolved several millennia after the onset of Holocene conditions.

Basándonos en los restos de industria lítica hallados en los niveles arqueológicos pertenecientes al Natufiense Reciente y al Neolítico Pre-cerámico A del yacimiento de 'Iraq ed-Dubb, Jordania, utilizamos un método estadísticamente cuantificable con el análisis de Sistemas de Información Geográfica para poder entender e interpretar aquellos cambios en el comportamiento humano que afectaron la estructuración interna del asentamiento. Nuestro estudio demuestra como la población Natufiense que habitó el asentamiento, caracterizada por una alta movilidad, casi no disponía de un uso específico del espacio en comparación con el mayor grado de organización del espacio interno del asentamiento durante el Neolítico Pre-cerámico A. Así pues, parece ser que esta mayor intensificación en la organización del espacio interno del asentamiento está directamente relacionada con una disminución en la movilidad residencial de la población. Además, el surgimiento de esta organización interna más formal de los asentamientos seguramente influyó en el posterior desarrollo de aquellas sociedades humanas, mucho más complejas, milenios después de la aparición de las condiciones específicas del Holoceno.

To what extent do hunter-gatherers, foragers, and farmers differentially create and use space within settlements? If the social creation of space among foragers and farmers was different, then how might these practices have been materialized, and how can researchers identify changes in the pace and tempo of routine practices through time? The answers to these deceptively simple questions are complex and evasive, and yet at the same time, critical in furthering our understanding of the human behavioral trajectory of emerging food production. One of the complications in addressing these questions is that there is no single correct answer: rather, we need a contextualized understanding of hunter-gatherers, collectors, foragers, and agriculturalists. In short, the answer is likely to be linked to issues of shifting mobility, and a mutable and flexible use of space dependent upon specific social and economic systems.

Exploring the Social Use of Space and the Forager-Farmer Transition

In the context of the prehistoric Near East, the pathways to fully sedentary communities from relatively mobile foragers were multibranched with people living in conditions of reduced residential mobility and then reverting back to more mobile life ways (Belfer-Cohen and Bar-Yosef 2000; Henry 1991). The Epipaleolithic of the Near East is divided into a number of temporal and cultural divisions (Table 1). Recent synthetic research (Bar-Yosef 2002; Byrd 2005; Henry 1989) has outlined the economic and cultural diversity within these cultural periods. Multi-season occupation, or even

Ian Kuijt ■ Department of Anthropology, University of Notre Dame, Notre Dame, IN 46556, (ikuijt@nd.edu)
Nathan B. Goodale ■ Department of Anthropology, Hamilton College, Clinton, NY 13323, (ngoodale@hamilton.edu)

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Table 1. Summary of Relevant Near Eastern Culture Historical Sequence*.

Period	Cultural Horizon	Calibrated Date Range
Middle Epipaleolithic	Geometric Kebaran	18,000-14,500
Late Epipaleolithic	Early Natufian	14,500-12,800
	Late Natufian	12,800-11,700
Pre-Pottery Neolithic	Pre-Pottery Neolithic A	11,700-10,500
	Early Pre-Pottery Neolithic B**	10,500-10,100
	Middle Pre-Pottery Neolithic B	10,100-9250
	Late Pre-Pottery Neolithic B	9250-8700
	Pre-Pottery Neolithic C	8600-8250

*(Drawing on Bar-Yosef 2003; Byrd 2005; Goring-Morris and Belfer-Cohen 1997; Kuijt and Goring-Morris 2002; Munro 2004).

**The PPNB is traditionally subdivided into an Early, Middle, Late and Final PPNB. Debate exists as to the existence and potential time span of an Early PPNB phase. It is not at all clear, however, if such a cultural-historical construct is supported by archaeological data. While recognizing the historical precedent of the EPPNB phase, researchers have yet to demonstrate that practices within Early PPNB communities were significantly different from Middle PPNB communities.

residing in a settlement for the majority of the year, first appeared in the late Epipaleolithic during the Early Natufian tradition (14,500–12,800 cal B.P.) (Belfer-Cohen and Bar-Yosef 2000; Hardy-Smith and Edwards 2004; Lieberman 1993) but may have had much earlier roots in Early Epipaleolithic (cf. the occupation at Ohallo II see Nadel et al. 1995, 2006). While Early Natufian communities thrived for approximately 1,500 years, the degree of sedentism declined for the following millennium during the Late Natufian. People eventually shifted to greater residential permanence during the Early Neolithic starting around c. 11,500 years ago (Belfer-Cohen and Bar-Yosef 2000; Grosman 2003:572; Kuijt and Goring-Morris 2002; Twiss 2007).

Early Natufian societies are often characterized as complex hunter-gatherers with the associated characteristics of social organization and economic intensification (Bar-Yosef 2002; Belfer-Cohen and Bar-Yosef 2000; Goring-Morris and Belfer-Cohen 1998). After the Early Natufian, Late Natufian populations appear to be more typical mobile hunter-gatherers with increased residential mobility (Bar-Yosef 1998:168, 2002:129–131; Goring-Morris and Belfer-Cohen 1998:80–82; Munro 2004). Early Neolithic communities, and more specifically, those of the Pre-Pottery Neolithic A period, are broadly characterized as being complex forager-collectors, with elaborate chipped and ground stone tool technology, and living in more elaborate residential communities. While there is no question that these groups were engaged in various levels of wild plant manipulation, researchers generally agree that there is no systematic evidence for the appearance of domesticated plants at this point.

Discussion of the broad evolutionary shifts from the Natufian to the early Neolithic has largely centered on: (1) climatic change and the onset of cold and dry conditions of the Younger Dryas (e.g. Goring-Morris and Belfer-Cohen 1998), (2) the fragility of complex social frameworks (Belfer-Cohen and Bar-Yosef 2000:23–24) and, (3) population dynamics (Henry 1989). Beyond such broad evolutionary considerations, researchers have started to develop detailed understandings of changing practices of lithic technology within and between different stages of the forager-farmer transition (e.g. Belfer-Cohen 1994; Belfer-Cohen and Goring-Morris 1996). There are, however, surprisingly few studies that have explored the degree of spatial variation of lithic tools and technology within occupation phase, let alone between different phases of occupation of the same settlement. In this paper we argue that such studies can significantly contribute toward our understanding of broader, and largely unrecognized, patterns in general, and more specifically, help us identify significant changes in the ways in which spaces were used within settlements, practices were materialized, and how settlements were structured through human action.

We believe that intra-site patterning, specifically the spatial variability in cultural materials, can be used to track some of the shifts in intra-community organization. We identify two trends; first, an increased formalization in the use of space through time, and second, the clear separation of the spa-

tial organization of practices, such as the location of flintknapping, refuse disposal, and where select activities occurred. These patterns reflect the variable pulses of changing settlement systems. At the broadest level we argue that intra-community organization during the Early and Late Natufian was different from those of early Neolithic communities. To make this argument we draw upon data from the site of Iraq ed-Dubb, Jordan (Kuijt 2004; Kuijt and Goodale 2006). The site contains occupations from the last hunter-gatherer/forager populations (Late Natufian) to some of the earliest relatively sedentary collector/agriculturalist communities (Pre-Pottery Neolithic A) in the Near East. Utilizing the lithic remains from the Late Natufian and Pre-Pottery Neolithic A (or PPNA from here forward) occupations of 'Iraq ed-Dubb, we work toward a quantifiable statistical approach incorporating Geographic Information Systems analysis. This enables us to document and better understand changing systems of how people used space and the variability accompanying these occupations. On this basis, we argue that the Late Natufian people were relatively mobile and had fairly nondelineated use of space compared to a more delineated use of space during the PPNA. With corroborating evidence from published literature on intra-community organization from Early Natufian and PPNA sites, we argue that intensified intra-community organization of space occurred hand in hand with decreased residential mobility. While there is variation, it appears that the emergence of a higher degree of formal intra-community organization likely aided in the development of much more complex human societies that evolved several millennia after the onset of Holocene conditions.

Even though mixing will have occurred between stratigraphic layers, the use of well-established cultural historical understandings of lithic typology in combination with confirmatory and exploratory data analysis statistical methods, allows us to separate assemblages from the multicomponent site with a complex stratagraphic record. While there are some technological similarities between these two time periods, at the same time there are several distinct tool types for different period tool kits that make it possible to separate different occupation periods (Belfer-Cohen 1994; Belfer-Cohen and Goring Morris 1996).

Archaeological Background

The Near Eastern archaeological record of the Late Epipaleolithic (14,500—11,700 cal B.P.) (Table 1) of the southern Levant is relatively well understood but highly complex. The changes we are concerned with in this paper occurred in the geographic area approximately incorporating Mount Carmel, the Galilee, and the Jordan Valley, broadly known as the "Natufian Homeland" or "core Natufian area" (Bar-Yosef 1998; Hardy Smith and Edwards 2004:257; Valla 1998). According to Bar-Yosef (1998:68), Early Natufian tradition (14,500–12,800 cal B.P.) hamlets in the "Homeland" are viewed as a "reaction to an abrupt environmental change that necessitated a shift of resource scheduling." This general improvement in climate, referred to as the Bölling-Alleröd interstadial (Baruch and Bottema 1991), is an environmental shift to warmer and wetter conditions just before the end of the last glacial maximum (Bar-Yosef 2002:106). With the onset of the Younger Dryas, a recognized global climatic episode of cold and dry conditions (Kudrass et al. 1991), Late Natufian (12,800–11,700 cal B.P.) peoples reverted to more mobile settlement systems, possibly as an adaptation to shrinking resource packages (Bar-Yosef 1998:168, 2002:129–131; Goring-Morris and Belfer-Cohen 1998:80–82). Evidence of stress among Late Natufian populations (Bar-Yosef 1998; Belfer-Cohen et al. 1991:421–422; Smith et al. 1984) and the subsequent reversion in the Late Natufian to higher residential mobility and smaller group size (Bar-Yosef 1998; Belfer-Cohen and Bar-Yosef 2000; Goring-Morris and Belfer-Cohen 1998), were likely significant contributions to how people adjusted their settlement strategy to cope with changing social and natural environments.

After the Younger Dryas, PPNA (11,700–10,500 cal B.P.) peoples established relatively sedentary communities in the southern Levant with an increased reliance on plant foods (Bar-Yosef 1998; Byrd 2005; Kuijt and Goring-Morris 2002; Twiss 2007). These communities, possibly under the influence of ideas from the northern Levant, were later replaced with new larger villages that housed several hundred people during the Middle Pre-Pottery Neolithic B (MPPNB) (Gebel 2002; Rollefson 1998, 2004). At the end of the PPNB, the large villages of the Late PPNB collapse and people

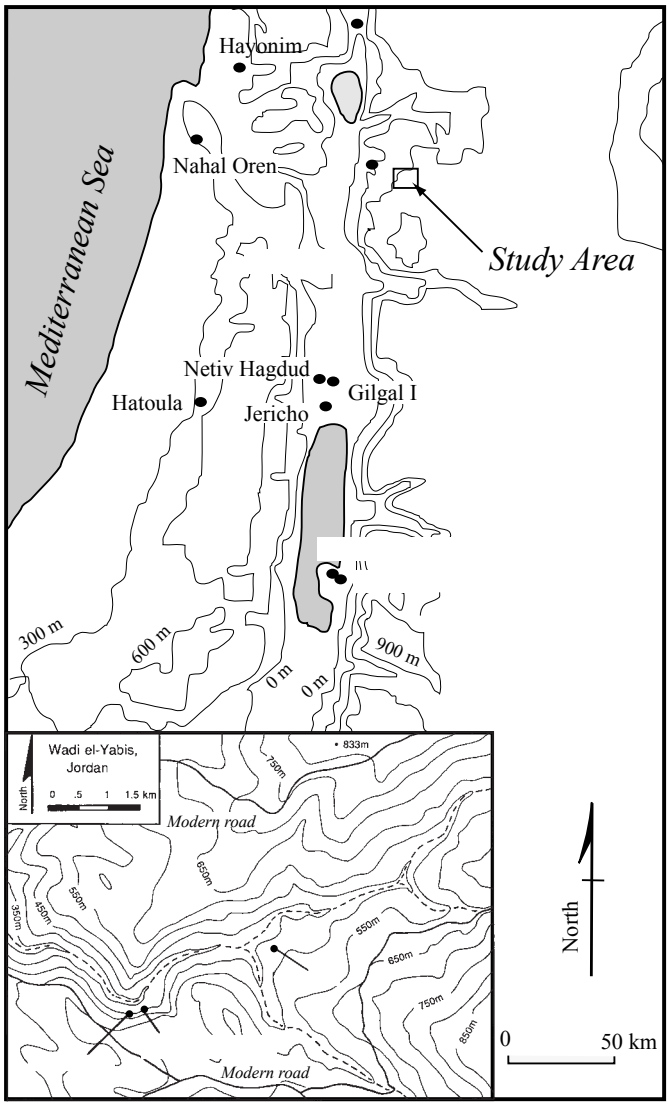

Figure 1. Map of the study area and location of 'Iraq ed-Dubb.

opted for a more mobile lifestyle focused on animal husbandry characterized by ephemeral and/or reused PPNB architecture (Kuijt 2000; Rollefson 1998:116).

'Iraq ed-Dubb

'Iraq ed-Dubb is located approximately 7 km northwest of Ajlun, Jordan. The cave of 'Iraq ed-Dubb is one of several caves and rock shelters along a limestone escarpment 150 m above the extensively vegetated part of the Wadi el-Yabis (Figure 1). The site encompasses approximately 150 m^2 within the cave and likely doubles this amount on the terrace at the mouth of the cave. Although natural and anthropogenic processes have mixed some of the cultural sediments, dating of intact deposits have indicated that the upper deposits with structures date to the PPNA and the underlying deposits and those extramural to the structures largely date to the Late Natufian. The site was excavated for three field seasons and in total recovered two oval stone structures, multiple pit features, fire hearths, and burials (Figures 2 and 3) (see Kuijt 2004 for a detailed description of features and architectural

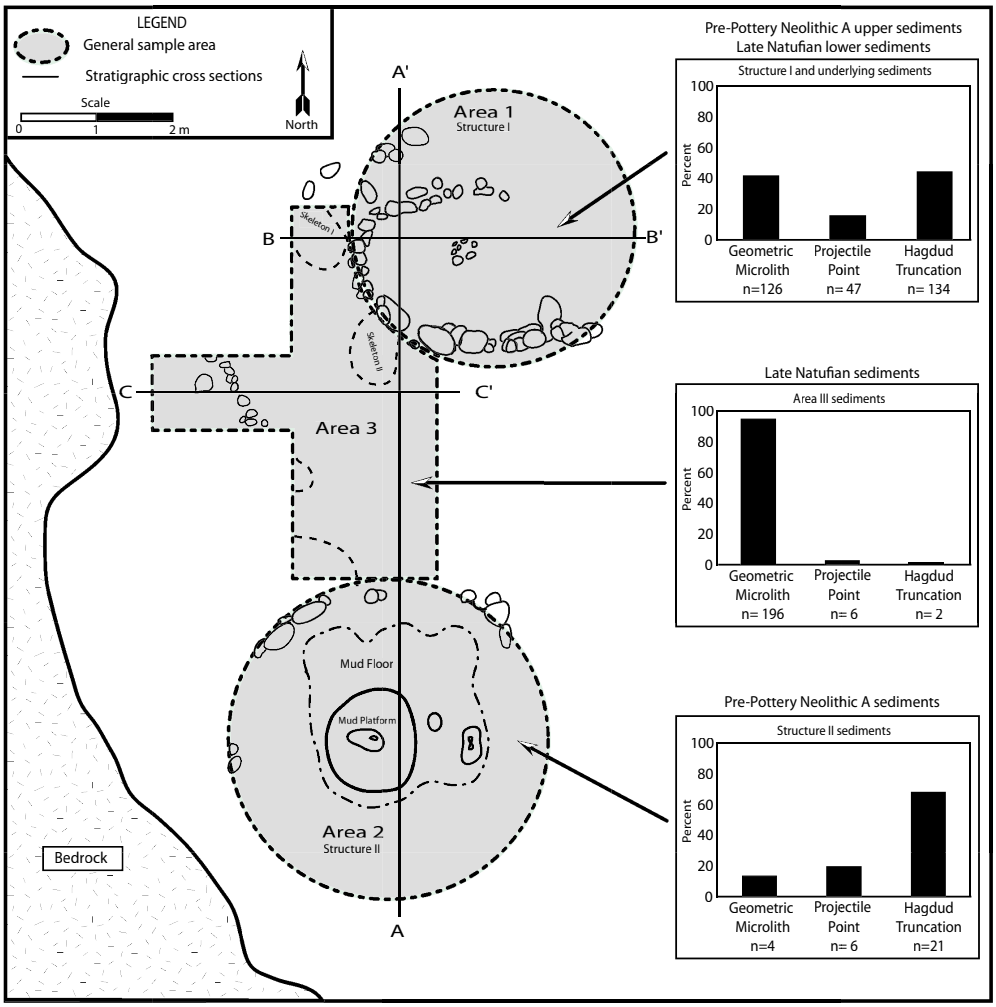

Figure 2. Site map of 'Iraq ed-Dubb and density of temporally diagnostic tool types by area.

elements). All of these artifacts were situated within less than 1.5 m of vertical cultural fill and most of the excavation units were taken to bedrock. Each structure was 4 to 5 m in diameter and had mud plaster floors. Structure I was almost entirely excavated, and had multiple episodes of mud floor-plastering events and an internal fire hearth. Beneath Structure I were several Late Natufian adult and subadult burials. All of the burials lacked grave goods and were placed in small hollows between bedrock outcrops (Kuijt 2004). Structure II had large grinding and anvil stones inset into the floor with a stone collar foundation and a central 10 to 15 cm circular mud platform.

The site of 'Iraq ed-Dubb is one of only a few sites in the Mediterranean Zone identified with both Late Natufian and PPNA occupations containing well-dated sediments attributed to both periods (Kuijt 2004; Kuijt and Goodale 2006). Because the excavations at 'Iraq ed-Dubb provide a clear example of the transition from Late Natufian to PPNA adaptive strategies, this study addresses the role of lithic tools and use of space during this change in settlement systems. While illuminating the characteristics of both the Late Natufian and PPNA lithic assemblages, this study will set the lithic technology into broader anthropological questions of settlement, intra-community organization, and residential mobility within the Late Natufian and PPNA occupations of 'Iraq ed-Dubb.

Figure 3. Artist reconstruction of 'Iraq ed-Dubb during the PPNA occupation. Illustration by Eric S. Carlson.

Analysis and Interpretation of the 'Iraq ed-Dubb Chipped Stone Industry

During the excavation of 'Iraq ed-Dubb, approximately 50,000 lithic artifacts were recovered including high percentages of tools indicative of the Late Natufian and the PPNA (Table 2). The tool assemblage is comprised of 1,102 artifacts, which are the focus of this study. The datasets representing both Late Natufian and PPNA loci (as defined in Table 2) contain approximately the same number of tools and tool types, suggesting that our patterns are not influenced by richness and/or diversity. Moreover, due to space limitations in this study we are only addressing the spatial patterns and different activities associated with stone tools. Future research will focus on debitage analysis. Lithic artifacts were recovered from 32 loci. As seen in Figure 4, Areas 1 and 3 contained most of the lithic tools while Area 2 contained far less. This pattern is in part due to the depth of excavation where sediments were largely left intact below the floor of Structure II/Area 2, while Areas 1 and 3 were excavated to bedrock. Tool types include various nongeometric/geometric microliths, El-Khiam and Salibiya projectile points, Hagdud truncations, scrapers, burins, perforators, sickle blades, bifacial tools, various retouched blades, bladelets, and flakes (see Kuijt and Goodale 2006 for a comprehensive description of the chipped stone from 'Iraq ed-Dubb).

Normative typological analysis is the main method used to document late Pleistocene and early Holocene Near Eastern lithic tool assemblages. Despite considerable field research there is ongoing debate among archaeologists as to which tool types are characteristic of individual cultural-historical periods (see Belfer-Cohen 1994; Belfer-Cohen and Goring-Morris 1996; Finlayson et al. 2003; Garfinkel 1996; Nadel 1997:133–134 for overviews of the problem). The tool types that are important in this debate are microliths (both nongeometric and geometric forms), projectile points (both el-Khiam and Salibiya forms), truncations (both Hagdud and Gilgal forms, however, only Hagdud truncations are present in the 'Iraq ed-Dubb assemblage), and large, heavy utility biface picks, axes, and chisels (Figure 5). Researchers differ as to which tool types are, or are not, characteristic of different periods. In our analysis we have eliminated specific tools for analysis, and are not employing bifaces as a key to detecting PPNA assemblages. This is not to reduce their importance, but given that only three bifaces were found at the site (Table 2) they are not a major data set for analysis. We have not included them in the chi-square analysis below due to the minimum sample size expectations of $N > 5$. However, because they are crucial to defining a PPNA lithic industry, they are utilized in the other pattern recognition and exploratory statistical tests provided later. Additionally, all of the bifaces were

Table 2. Total Tools by Typological Category Ordered by *Locus used for the CA and by **Intuitive Group used for the DA.

Locus*	Intuitive**	Back[1]	Biface[2]	Burin[3]	Core[4]	Geo[5]	Non[6]	Notch[7]	Perf[8]	Proint[9]	Ret[10]	Scrap[11]	Sickle[12]	Trunc[13]
Extramural Area 3														
001	Extra	0	0	0	0	8	0	0	0	6	0	0	0	0
004	Extra	2	0	2	18	80	54	4	1	6	16	6	1	4
008	Extra	0	0	0	0	2	1	0	0	0	1	0	2	0
013	Extra	0	0	0	2	6	11	0	0	0	1	0	0	0
020	Extra	0	0	0	0	7	7	0	0	0	0	0	0	0
025	Extra	1	0	2	8	61	41	0	6	0	11	4	0	1
032	Extra	1	0	1	4	8	7	0	1	1	1	2	0	0
036	Extra	1	0	3	1	5	4	3	1	5	11	7	0	0
038	Extra	0	0	0	0	2	0	0	0	0	0	0	0	0
039	Extra	0	0	0	0	4	3	1	0	0	0	0	0	0
042	Extra	0	0	0	1	6	2	1	0	2	1	0	0	0
046	Extra	1	0	0	0	2	0	0	0	0	0	0	0	1
Structure I Area 1														
007	Upper Floor	5	0	0	1	10	17	2	7	18	5	3	2	17
014	Mixed Floor	1	0	1	7	23	12	2	4	16	7	2	2	58
016	Mixed Floor	0	0	0	3	5	4	0	0	3	0	1	1	21
017	Mixed Floor	0	0	1	0	0	1	0	0	0	1	0	0	1
021	Mixed Floor	0	0	0	0	0	0	0	0	0	0	1	0	0
010	Lower Floor	0	0	0	2	10	6	1	0	0	2	1	0	5
012	Sub Floor	3	0	0	0	0	0	0	2	0	0	0	0	3
019	Sub Floor	0	0	2	3	27	23	0	0	9	13	10	0	11
023	Sub Floor	0	0	2	2	8	3	1	0	1	2	2	0	3
029	Sub Floor	0	0	0	0	2	2	0	0	0	0	1	0	0
033	Sub Floor	0	0	1	1	5	2	0	0	0	0	0	0	3
037	Sub Floor	0	0	1	0	2	0	0	0	0	3	1	1	5
Structure II Area 2														
028	Fill	0	0	0	2	0	2	1	2	2	5	9	0	8
030	Floor	0	2	0	2	2	7	3	0	6	23	4	8	13
037	Sub Floor	0	0	1	2	2	0	1	1	1	6	1	1	5
Total		16	3	18	59	300	224	23	28	78	115	49	20	163

[1]Back = Backed Blades; [2]Biface = Biface, Picks, Axes and Chisels; [3]Burin = Burins; [4]Core = All Cores; [5]Geo = Geometric Microlithis; [6]Non = Non-Geometric Microliths; [7]Notch = Notches and Denticulates; [8]Perf = Perforators; [9]Point = el-Khiam and Salibiya Points; [10]Scrap = Scrapers; [12]Sickle = Sickle Blade; [13]Trunc = Hagdud Truncations

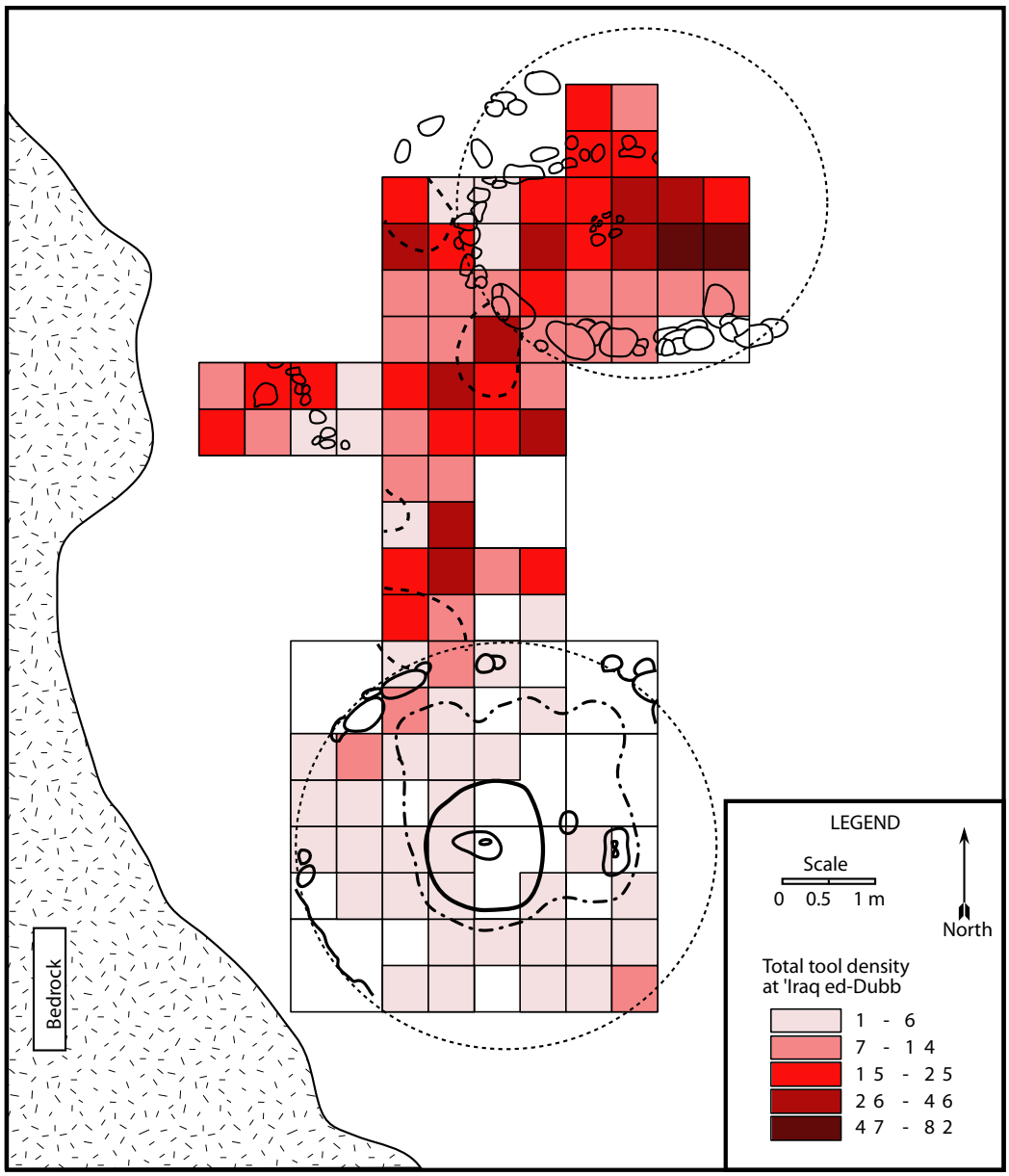

Figure 4. Geographic Information Systems plot of total tools across all areas of 'Iraq ed-Dubb.

found in association with PPNA sediments or those that were likely disturbed by the PPNA occupation. While it is generally accepted that Hagdud truncations, and el-Khiam and Salibiya point types were new inventions that are temporally restricted to the PPNA, researchers continue to debate if microliths were continually manufactured from the Natufian for 300–500 years into the Neolithic. Nonetheless, it appears that microlithics at least drop significantly (Yartah 2002), if not completely (Garfinkel 1996; Finlayson et al. 2003; Kuijt and Goodale 2006) out of the PPNA lithic tool kit by the early PPNA and their presence is likely due to mixing. In other words, significant percentages of microlithics should be indicative of Natufian components.

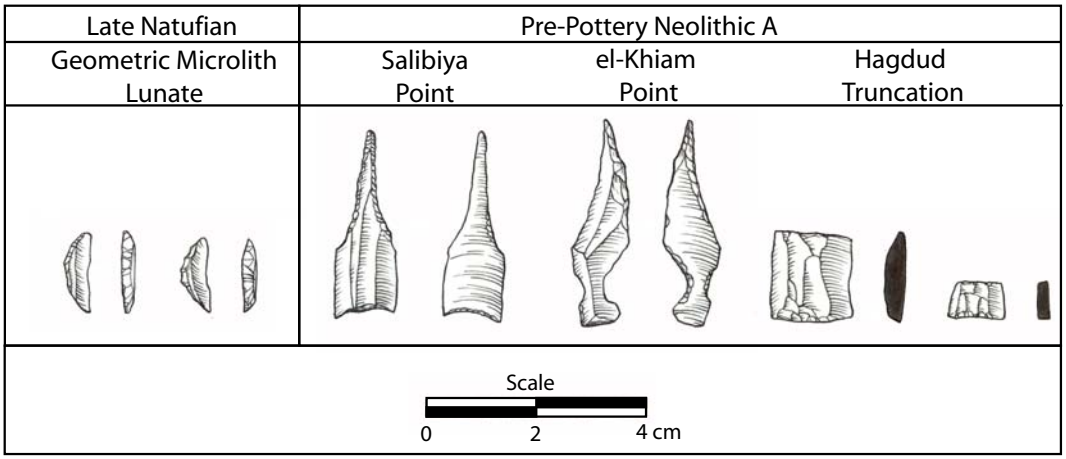

Figure 5. Diagnostic tool typologies for the Late Natufian and PPNA.

Illustrating Two Disparate Occupations

In light of the debate on inter-assemblage variability, it is necessary to address site scale variability through time before exploring how these data help us understand the behavioral components that the position of these artifacts may represent in the larger issue of the forager/farmer transition. To clarify the extent to which different tool types overlap, the next section of the paper attempts to assign the loci affiliated with each of the two occupations at 'Iraq ed-Dubb. The ^{14}C data shown in Figure 6 illustrate a clear hiatus of ca. 550 years between the Late Natufian and PPNA occupations. To analyze the chronological separation of different diagnostic tool types, we utilize both horizontal and vertical relationships and consider the presence and/or absence of certain tools types in different occupational zones.

To understand some of the detailed dimensions of variability and how this fits with cultural-historical sequencing, we explore some of the spatial patterning of diagnostic artifacts. First, does the spatial occurrence of lithic tool types attributed to the Late Natufian and the PPNA illustrate spatial patterning horizontally across the site? Formally, the question is: can we elucidate differences with respect to tool typologies that are expected to be restricted to either the Late Natufian or the PPNA on a horizontal scale? Figure 2, which depicts the overall pattern in Area 2, illustrates that the interior of Structure II exhibits a very high count of truncations and very few geometric microliths. This fits well with the radiocarbon dating that assigns this structure to the PPNA period (Kuijt 2004). Area 3 shows a very high percentage of geometric microliths indicative of a Late Natufian occupation. Area 1 contains a mixture of tool types associated with both periods. These initial results support interpretations that Areas 2 and 3 were discrete occupations containing tools representative of a Late Natufian occupation in Area 3 and a PPNA occupation in Area 2 (see Kuijt and Goodale 2006 for a comprehensive analysis).

Second, do the patterns in Structure I exhibit a Late Natufian versus a PPNA signature on a vertical scale? As demonstrated in Figure 7, the sequence of vertical deposition reveals that the lower stratigraphic levels (green) contain a high number of geometric microliths with some intrusive PPNA tools. The middle levels, most likely to have been mixed by the construction and re-building of Structure I (blue), are characterized by declining numbers of geometric microliths with increased numbers of projectile points and Hagdud truncations. In the upper levels (red), there is a decrease in microliths and high quantities of PPNA tools. However, there are still some microliths in the upper level. We believe the occurrence of the microliths are linked to site formation processes where earlier tool forms were mixed during the construction of the later PPNA structure floors. The fact that it is very evident that some PPNA tools have changed in their vertical position supports this view.

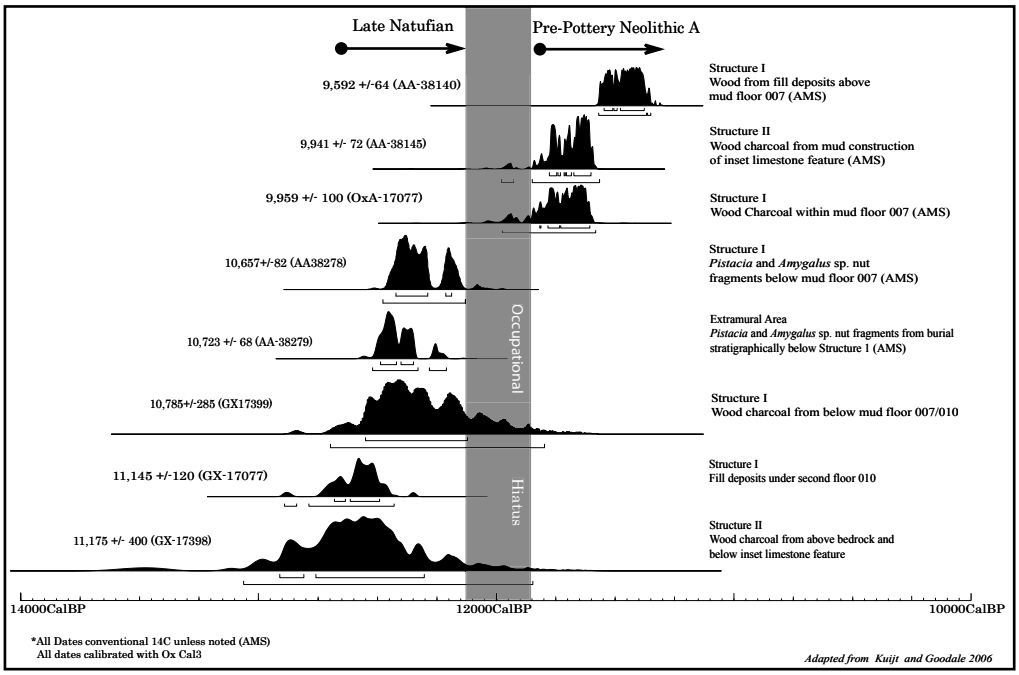

Figure 6. Calibrated ^{14}C data demonstrating a hiatus between the Late Natufian and PPNA occupations. Adapted from Kuijt and Goodale 2006.

Finally, can we determine if these spatial patterns are statistically significant? To demonstrate this we examined the stratigraphic layers utilized in both the vertical and horizontal analysis by dividing them into Late Natufian (Area 3; green), mixed (Area 1; blue), and the PPNA (Area 2 and Area 1; red) as the independent variable and tool type (geometric microlith, projectile point, and Hagdud truncation) as the dependent variable. As demonstrated by chi-square analysis, these patterns are statistically significant ($\chi^2 = 229$; $df = 4$; $p = <.0001$; $\Delta R \times C = .3053$). While these results clarify the relationship of certain tool types present in an overall picture of the excavation area and indicate what areas were likely utilized during the Late Natufian and the PPNA, they do not allow for further examination of how lithic tool kits may help to identify certain aspects of settlement organization such as the existence of spatially delineated activity areas. To accomplish this we employ exploratory data analysis and confirmatory data analysis techniques to extract patterns of tool variability in spatially restricted areas at 'Iraq ed-Dubb. The subsequent analysis presented below demonstrates that we can statistically define the tool kits of the Late Natufian and the PPNA to make interpretations on how the site was structured differently through the transition from the Late Natufian to PPNA.

Identifying Distinctive Tool Assemblages

To address spatial organization we utilize exploratory data analysis (EDA) and correspondence analysis (CA) to detect overall patterns of lithic data and to evaluate evidence for a subdivision of tools between each occupation. Second, we employ a more confirmatory data analysis technique, discriminate analysis (DA), to statistically test the results of the correspondence analysis and verify the patterns of the two cultural occupations that we can then interpret.

The lithic data for this study were obtained from 32 loci encompassing two structures and an extramural area from approximately 1.5 m of cultural sediments. The data used are representative of all lithic tools (Table 2) found in association with all loci excavated during the 1989–1991 seasons. We did not analyze the materials recovered

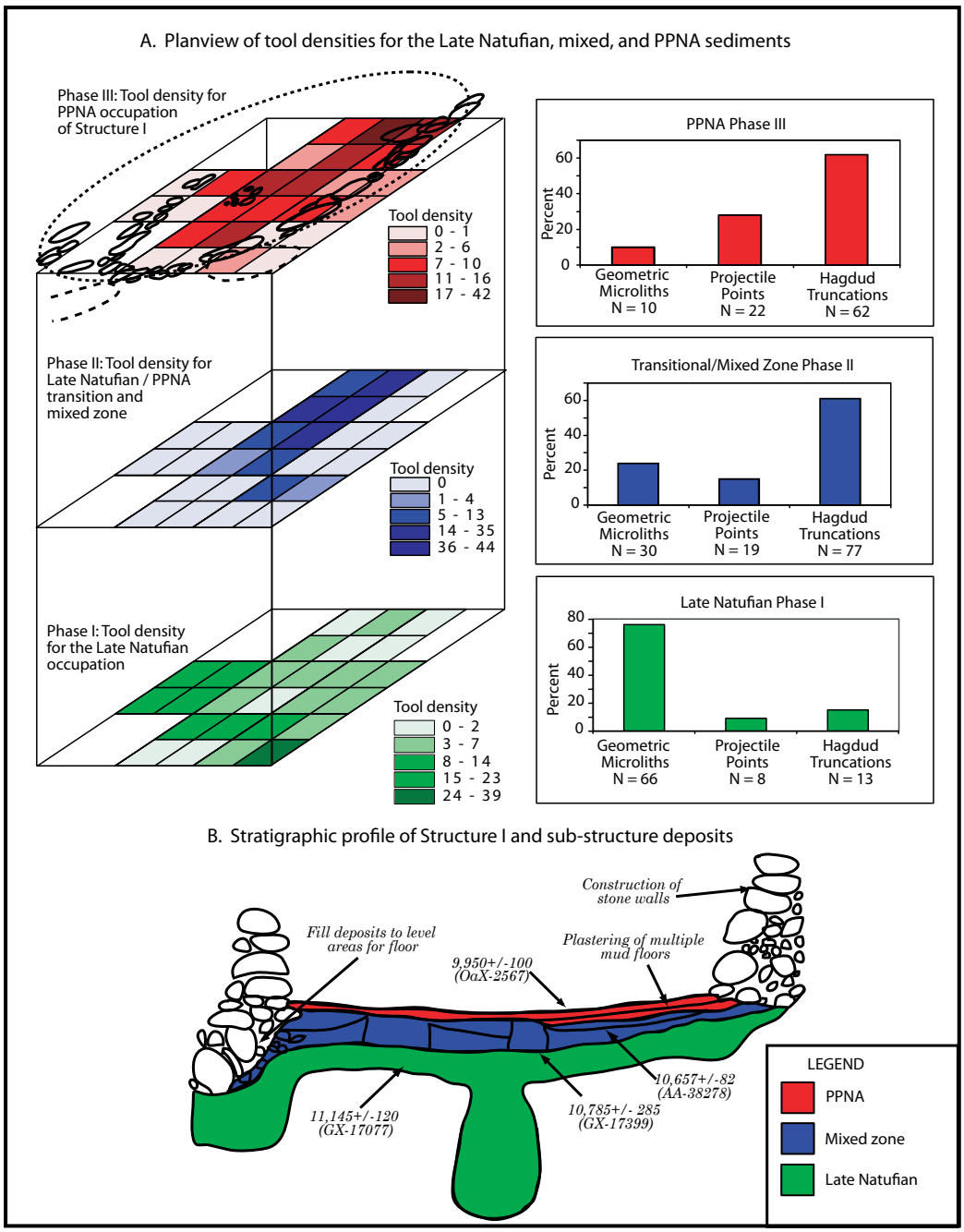

Figure 7. Geographic Information Systems plot and densities of diagnostic tools on a vertical scale of Structure I.

from locus 000, representing approximately the top 10–20 cm of each unit consisting of mixed prehistoric, Late Bronze Age, and modern occupations. Four radiocarbon dates associated with lithic materials also facilitated the separation of occupations at 'Iraq ed-Dubb.

Correspondence Analysis

Correspondence analysis (CA) is an exploratory data analysis technique designed to analyze sim-

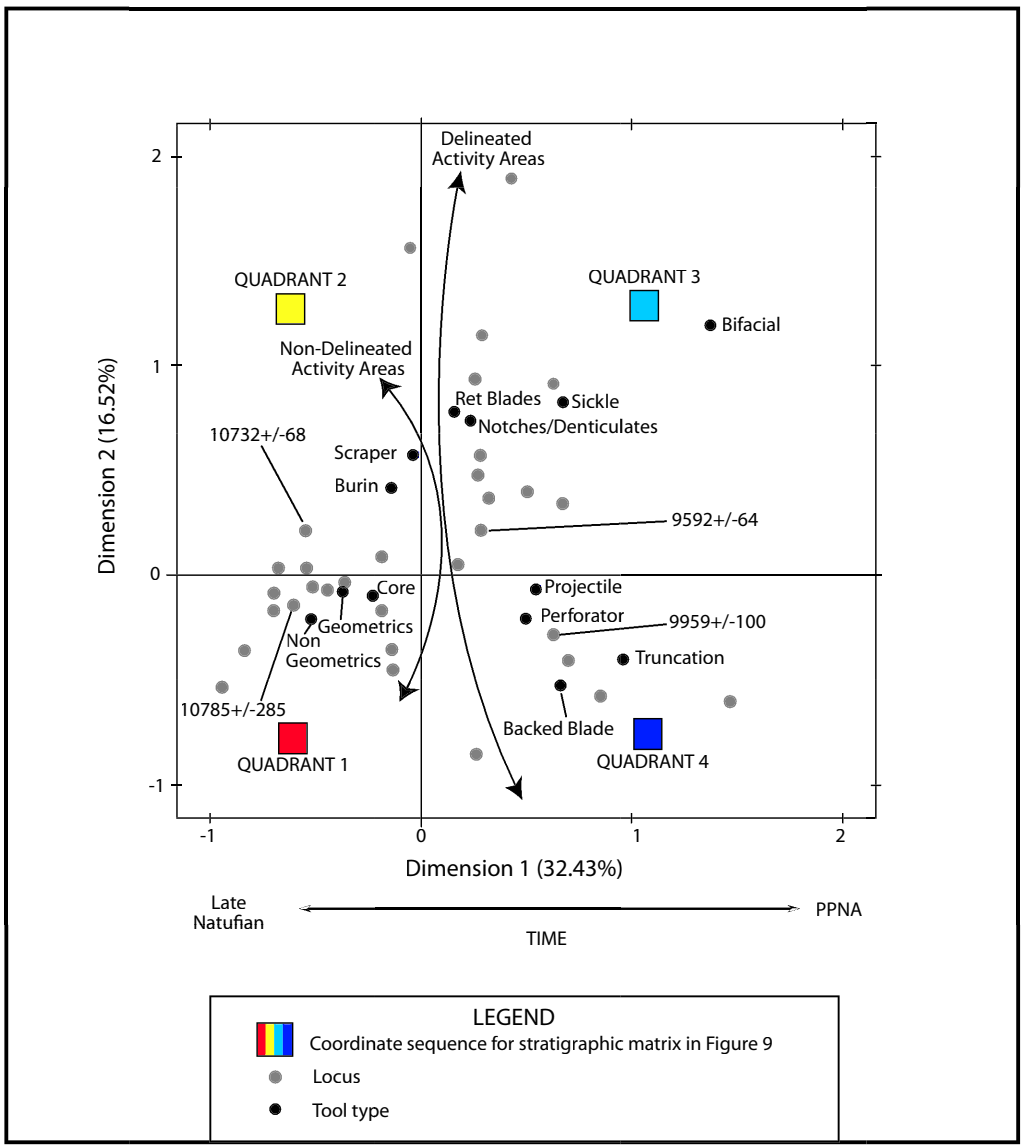

Figure 8. Correspondence analysis with loci as the dependent variable and tool type as the independent variable.

ple two-way and multi-way tables containing some relative measure of correspondence between cases and variables. CA is an analysis technique where data can be represented in a Euclidean coordinate system that is very similar to principal components analysis (PCA) (Shennan 2001). Shennan (2001:308) notes that while PCA provides the foundations of to the CA technique, PCA is not suited for the analysis of data consisting of numerical counts. Conversely, CA is specifically designed for direct measurement data such as counts of lithic tool types or ceramic sherds, which arguably is the most common type of data in archaeology. CA provides a scatter plot in Euclidean distance illuminating patterns in numerical data that reflect relationships between cases and variables. CA was originally developed in France and gained the appreciation of French archaeologists (Djindjian 1985), Scandinavian archaeologists (Madsen 1988), and later of North American archaeologists focused on the Southwest ceramics (Duff 1996). This analysis was conducted with the raw data as it does not require

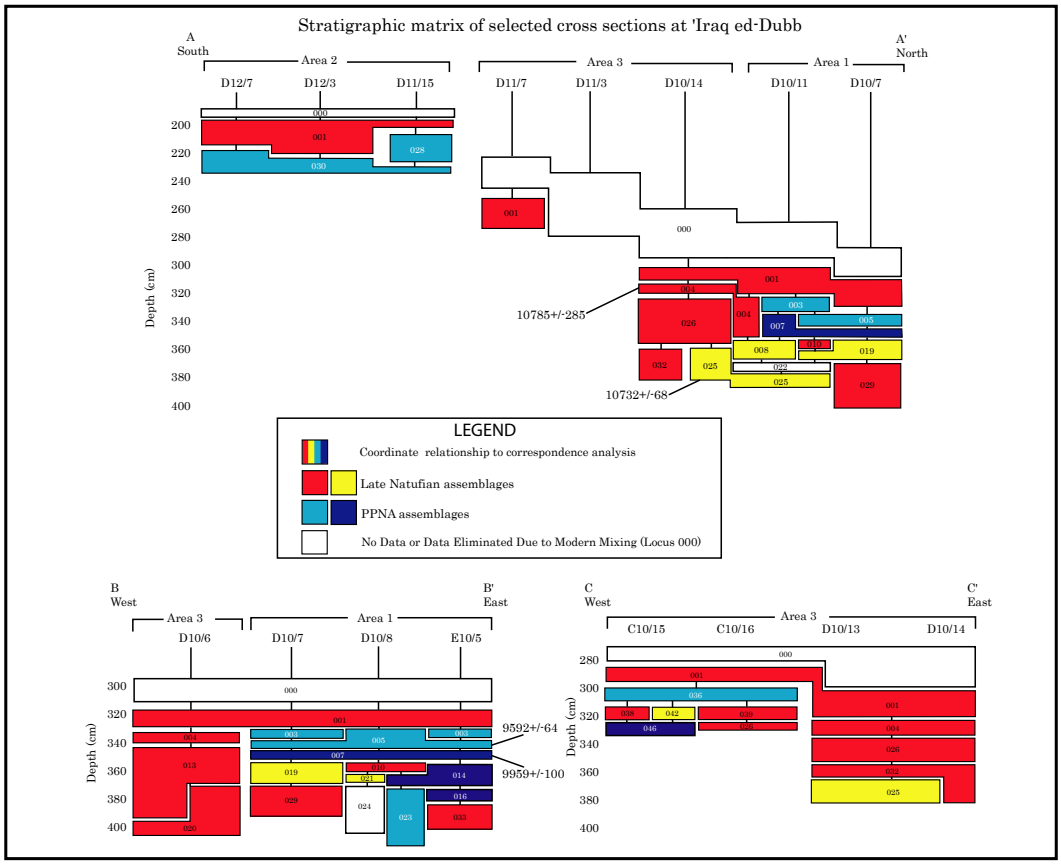

Figure 9. Stratigraphic matrix of 'Iraq ed-Dubb. Section lines A-A', B-B', and C-C' follow those labeled on Figure 2. Color sequence is coded to Figure 8.

the data within a variable to be normally distributed to extract patterns of variability.

The CA was run in the statistical program SAS v. 8.0 with the data at the locus level presented in Table 2 (see Figure 8). Several interesting patterns emerge from this analysis. First, geometric microliths, nongeometric microliths, cores, burins, and scrapers exhibit negative loadings on Dimension 1. Dimension 1 also provides positive loadings on Hagdud truncations, projectile points, perforators, backed blades, retouched blades, notches and denticulates, sickle blades, and bifacial tools. We interpret Dimension 1 to reflect different periods of occupation, clearly dividing the diagnostic tool types associated with the Late Natufian period (geometric microliths and nongeometric microliths), from those associated with PPNA period assemblages (projectile points and Hagdud truncations).

Second, Dimension 2 is primarily responsible for the vertical distribution on the graph of the tools and loci where those associated with the left quadrants are tightly clustered with the juxtaposed dispersed pattern on the right. Dimension 2 separates Late Natufian loci that have negative loadings on geometric microliths, nongeometric microliths, and cores in Quadrant 1 from those with positive loadings on scrapers and burins in Quadrant 2. Dimension 2 also separates PPNA loci having negative relationships with projectiles, truncations, perforators, and backed blades (Quadrant 3) from those with positive relationships including retouched blades, notches and denticulates, sickle blades, and bifaces (Quadrant 4).

As mentioned, this graph depicts a tight clustering of what are likely Late Natufian period loci and tools compared to the PPNA period dispersed distribution. While this patterning can be inter-

preted from multiple perspectives, one interpretation is that Late Natufian and Pre-Pottery Neolithic A period groups organized and used space in very different ways. In contrast to the more formal use of space during the Pre-Pottery Neolithic A period, the Late Natufian people did not restrict their activities to specific spatial areas of the cave. Nearly every locus of the Late Natufian occupation shows the occurrence of the entire range of typological variability. In contrast, the loci affiliated with the PPNA are much more spread out with each locus more likely to be different from the next suggesting formal activity areas where certain tasks occurred. We suggest that this pattern reflects an intensified degree of PPNA period site organization and the formalization of specific activity areas associated with decreased residential mobility.

When we plot the CA results in vertical and horizontal loci blocks from 'Iraq ed-Dubb (Figure 9), we see the relationship between loci and tools that are roughly comparable with the quadrant color scheme in Figure 7. All of the areas contain significant correlation to the Late Natufian within the upper most layer (locus 001). PPNA people do not appear to have used the areas extramural to their semisubterranean structures. It is not clear why this is the case; perhaps this is a function of shortness of the occupation or that major activities occurred out front of the rockshlelter. The lower levels of Structure II contain significant proportions of retouched blades, sickle blades, notches and denticulates, and bifacial tools (Figure 9, A-A' cross section), which is consistent with the PPNA date of 11,210–11,710 cal B.P. *(p = .95)* (Kuijt 2004:295, AA-38145; wood charcoal $\delta^{13}C$ = –25.2‰). (Calibrated at 2σ with the program OxCal 3.10 [Ramsey 1995, 2001].) Structure I contains significant proportions of tools associated with Quadrants 3 and 4 (Figure 7) in loci 003, 005, 007, 014, 016, and 023 representing floors and features associated with the structure. Locus 010, the second floor in Structure I, is anomalous, with a significant proportion of tools associated with the Late Natufian. Supported by the stratigraphic sequence of the rebuilding of Structure I, this anomaly may be explained by the use of earlier deposits containing Late Natufian tools to construct or level the PPNA floor of Structure I during the second occupation and/or rebuilding (represented as Locus 007). The lower levels within Structure I, not actually associated with the structure, contain a significant proportion of tools indicative of the Late Natufian. All of the extramural units have a significant number of tools associated with the Late Natufian, depicting the spatial constraint of the two occupations.

Discriminant Analysis

In contrast to correspondence analysis, discriminant function analysis (DA) presupposes the existence of a given number of known groups and is concerned with the allocation of cases that are collections of items to those groups to which they belong most appropriately (Shennan 2001:350). Briefly, DA plots the case membership in relationship to a centroid in a plot where the axes represent the discriminant functions that characterize the major dimensions of variation that differentiate groups allowing interpretation of the dimensions (e.g., temporal, spatial, or physical attribute variability) in a similar manner as CA (Shennan 2001). To our knowledge, DA has been in use in archaeology since the late 1970s (e.g. Bettinger 1979). While this technique has not been applied to Near Eastern prehistoric questions, the following discussion illustrates the utility of DA in confirming the patterns presented by the CA.

As DA assumes normality, each variable was transformed with LOG_{10} to correct for the positive skewness exhibited by each variable. Prior to taking the LOG_{10}, a small constant (.01) was added to each value to avoid null values for the transformation. As DA presupposes case membership to a group, each locus was grouped intuitively into one of the following classifications: Area 1: fill, first floor, second floor, or subfloor; Area 2: fill, floor, or subfloor; and Area 3. The analysis was run in SAS v.8.0 with the data provided in Table 2 by the intuitive groupings stated above. The maximum two discriminant functions were utilized explaining 71 percent of the variability. Both of the discriminant functions were statistically significant (χ^2 of Wilk's lambda*: p < .0001*) as were the differences between all seven intuitive clusters as measured by discriminant functions 1 and 2 (*F-ratio of centroids: F < .0001 and F < .0015 respectively*).

The overall trend is highlighted by the DA is most apparent when both functions are explored simultaneously. Both functions explain nearly the same percentage of variability with 36 percent and

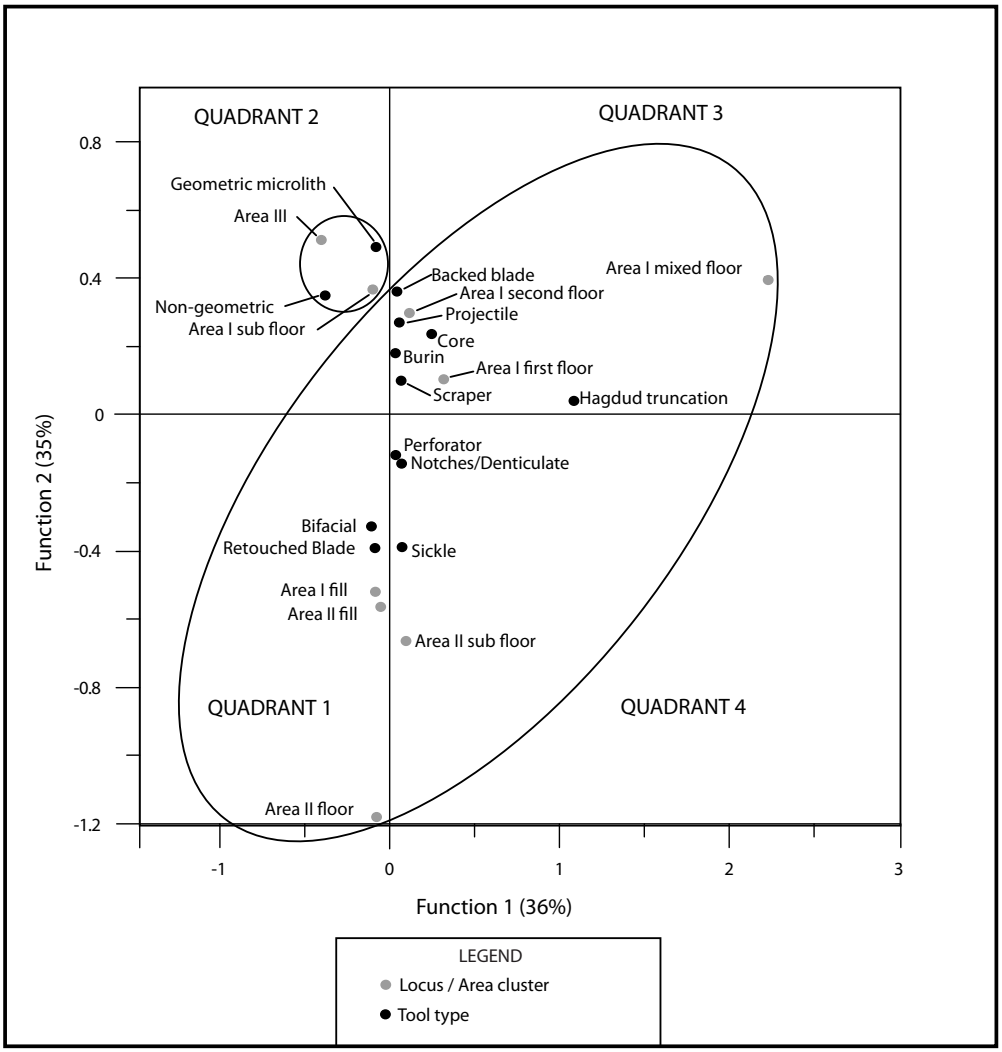

Figure 10. Discriminant analysis plot with area group as the dependent variable and tool type as the independent variable.

35 percent respectively. This confirms that the oval trend in Figure 9 is meaningful, which separates those loci affiliated with Area 3 and Area 1/ Structure I subfloor in Quadrant 2 from the loci affiliated with the PPNA occupation of Structures 1 and 2 shown in Quadrants 1, 3, and 4. The pattern in Quadrants 1, 3, and 4 are very different from Quadrant 2, indicating, again, as with the CA, that a diversity of discrete activity areas highlight PPNA occupation while homogeneous activity areas belong to the Late Natufian. In both the DA and CA analyses, geometric and nongeometric microliths were identified as contributing to certain loci more consistently than others, while the scattered distribution of the majority of the tools appears to reflect the PPNA occupation.

Discussion

Our analysis and interpretation is complicated by three factors. First, there are very few known Epipaleolithic and Neolithic sites that bridge the Late Natufian/PPNA culture history periods (a very significant period linked to the forager-farmer transition). Second, many Levantine Natufian and Neolithic sites were excavated before the introduction of systematic high-resolution dry sieving and flotation (Bar-Yosef 1998:166). In the excava-

tion of Jericho, for example, no sieving was employed. Third, even when sieving was employed in excavations, subsequent analysis of Late Natufian and Neolithic sites are undermined by other complications. For example, there are a limited number of sites that have been excavated with adequate recording to conduct this type of analysis, and even fewer that have been subsequently published in a manner that allows comparisons. Finally, and unquestionably the most challenging of these factors, researchers have yet to identify the degree to which human practices are, or not, systematically patterned within settlements. The analysis of the 'Iraq ed-Dubb materials provide an initial means to explore the changing degree of intra-community organization and inter-community relationships (e.g., Bar-Yosef 2002; Belfer-Cohen and Bar-Yosef 2000; Henry 1989).

In concert with a detailed understanding of changing diagnostic tools through time, the spatial patterning of artifact deposition can help us understand aspects of community organization during the forager-farmer transition, highlighting shifts in behavioral adaptations, and help us reconstruct the use of delineated and non-delineated activity areas. Excavations at select Natufian sites illustrate an interesting binary pattern of use: well-defined locations, such as inside structures, and other areas that are relatively homogenous (Hardy-Smith and Edwards 2004; Valla 1988). Hardy-Smith and Edwards (2004) argue that at the Early Natufian site of Wadi Hammeh 27 (Edwards 1991) the inhabitants "had not tailored their indifferent household sanitation practices to the long-term requirements of sedentary living" (Hardy-Smith and Edwards 2004:285). To substantiate their interpretation they note that 82 percent of 423,858 flake stone artifacts were recovered from inside two structures with the remaining 18 percent recovered extramurally. The structures' interior volumetric densities of flint artifacts reach 4,669 m^2. They argue that while there were apparent activity areas, activities were "carried out against the generalized backdrop of everyday domestic duties, rather than in specially allocated areas or purpose-built buildings" (Hardy-Smith and Edwards 2004:277). They also suggest that this pattern is seen at other sites occupied during the Early Natufian including Hayonim Cave (Bar-Yosef 1991; Belfer-Cohen 1988), the associated Hayonim Terrace (Henry et al. 1981), and Ain Mallaha (Valla 1988, 1991). While having a lower density of artifacts and no permanent structures, the pattern from the Late Natufian occupation 'Iraq ed-Dubb is strikingly similar to that Early Natufian occupation at Wadi Hammeh 27.

Nadel (1998:8) argues that the spatial pattern from Late Epipaleolithic settlements is relatively homogenous, and that nearly every archaeological locus contains the full gamut of typological variability. With the Late Natufian occupation at 'Iraq ed-Dubb, we see that everyday activities occurred in all areas of the site, and this has contributed toward a material homogenization of the tools recovered from individual loci. As such, the Late Natufian occupation(s) at 'Iraq-ed-Dubb appear to have had similar intra-community spatial organization, practices that resembled those of the preceding Early and Middle Epipaleolithic periods. Some of this patterning may be related to the absence of significant site furniture in the Late Natufian. Hardy-Smith and Edwards (2004:282) and Binford (1983:152–153) argue that under specific conditions, different types of site furniture, such as fire hearths, are likely to produce drop zones and spatial concentrations of materials. Echoing these general observations, the evidence from "Iraq ed-Dubb illustrates how Late Natufian peoples" practices were characterized by comparably less spatial segregation of activities, while PPNA populations appear to have carried out more formalized practices.

A number of recent studies, including that of Hodder and Cessford (2004), have drawn attention to the increasingly structured use of space and refuse management within large Neolithic villages. As one of the few available detailed studies, this allows us to look at the end of what must have been a long-term trajectory starting in the Epipaleolithic periods. At the moment, however, we have only a limited understanding of how and why the use of space shifted through the forager-farmer transition. Excavations at other PPNA sites provide hints of this transition. Further evidence for PPNA delineated activity areas and refuse management practices comes from the recently excavated site of Dhra', Jordan (Finlayson et al. 2003; Goodale et al. 2002; Kuijt 2001), and Wadi Faynan 16 (Finlayson and Mithen 2007). At Dhra', specific refuse middens were found as well as overall smaller densities of lithic artifacts on cleaned floors and occu-

pation surfaces. Other excavations at PPNA sites of Netiv Hagdud (Nadel 1997:126) and Qermez Dere (Watkins 1990) are inconclusive, but this may be due to limited sampling and excavation of relatively shallow areas. At Netiv Hagdud, for example, the limited excavation, both vertically and horizontally, has made it extremely difficult to phase individual loci, understand how these are chronologically related, and assess the taphonomic origins of individual deposits.

A more formal organization of space starting in the PPNA may have provided social and organizational advantages by segregating more distinct areas of space in the community and tailoring everyday tasks to the long-term requirements of sedentism. While beyond the scope of this paper, we suggest that the adaptation of formalized intracommunity organization during the early stages of the transition to agriculture served as a necessary organizational foundation for the development of more complex human societies. Despite the limited study of this topic, preliminary considerations (e.g., Flannery 2002; Hodder and Cessford 2004; Twiss et al. 2008) of large agricultural villages in the Pre-Pottery Neolithic B, illustrate a long-term trajectory of continually intensifying community organization from Epipaleolithic foragers to Neolithic villagers.

Conclusions

In this paper, our analyses allow us to track the origins of loci from two disparate occupations at ‘Iraq ed-Dubb. Based on this evidence we argue that tool kits can be identified for each occupation of the site, and demonstrate that the spatial patterns for each occupation are very different. The relatively nondelineated activity areas of the Late Natufian are consistent with the assertion that they were a relatively mobile population. In contrast, the PPNA occupation shows more intensive community organization with designated activity areas even for everyday domestic tasks. Finally, we suggest that the complete social and economic package that facilitated sedentism as a long-term viable strategy was only adopted with the emergence of later Pre-Pottery Neolithic period villages. In the Pre-Pottery Neolithic A period there is clear evidence for the development of early refuse management systems and highly delineated activity areas. We suggest that the development of formalized site organization, in conjunction with other ecological variations and human societal development, were both a byproduct of the transition to agriculture as well as facilitating growth and organization of Neolithic communities.

This analysis helps us understand some of the broader aspects of the pathway to human sedentism. While Natufian foragers/hunter-gatherers lived in a world that shared some material aspects with later Neolithic agriculturalists, including a substantial ground stone industry and the construction of substantial residential buildings, space within Late Natufian settlements was organized in a similar manner to preceding and other mobile societies. Subsequently, something quite different, in terms of the behavioral organization of space, began to happen in the early Neolithic with the development of more formalized uses of space. In Trevor Watkins words (1990:337), there may indeed be the “change of view from the house as a shelter, the centre of certain everyday activities, to the house as a home, the centre of the family,” and the place where humans began to tailor their organization to the long-term requirements of sedentism.

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Note

1. Researchers debate if the Natufian should be subdivided into two or three subphases. Traditionally, the Natufian has been divided into the Early Natufian (ca. 15,000–13,500 cal B.P.) and the Late Natufian (ca. 13,500–11,500 cal B.P.). Alternatively, Valla (1987) and Goring-Morris and Belfer-

Cohen (1998) argue that the Natufian period should be envisioned as consisting of the Early Natufian (ca. 15,000–13,500 cal B.P.), the Late Natufian (ca. 13,500–12,700 cal B.P.) and the Final Natufian (ca. 12,700–11,500 cal B.P.). In our view, there are merits to both arguments. For the purposes of this paper we use the general label of Late Natufian, but would like to stress that in using this label, we are not discounting a proposed revision of Natufian cultural-historical framework.

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