Chapter 10

Woodland Vegetation and the Exploitation of Fuel and Timber at Neolithic Çatalhöyük: Report on the Wood-charcoal Macro-remains

Eleni Asouti

This report details the results of the analysis of wood charcoal macro-remains retrieved through water flotation from a sequence of midden layers excavated in the South Area (broadly corresponding to excavation Levels VII-Pre-XII.D). Also treated are assemblages retrieved from domestic and external contexts other than middens in the North Area (Building 1) and the South Area (Levels VII-Pre-XII). First, an outline is given of the aims of the analysis and the various methodologies adopted for addressing them. Reporting on methodology includes the rationale for sample selection, subsampling in the laboratory, and the methods of quantitative analysis. Following these, the results of the analysis are presented by building level and phase. The final part of the paper summarizes the information obtained from the wood-charcoal assemblages on the composition of the Neolithic woodland catchments and the human strategies for their exploitation.

Aims and context of the analysis

Traditionally, the study of archaeological wood-charcoal macro-remains has been viewed mainly as a tool for reconstructing past vegetation and, by inference, climate patterns (Chabal *et al*. 1999; Figueiral & Mosbrugger 2000; Willcox 1992a). The value of wood charcoals derived from stratified archaeological deposits for the purpose of vegetation reconstruction has been widely recognized, particularly in relation to arid environments where the spatial and temporal resolution of pollen sequences can be compromised by the scarcity and poor preservation of pollen-bearing lake sediments (Asouti & Hather 2001). Other scholars have further drawn attention to the fact that archaeological charcoal macro-remains almost universally represent the residues of purposefully-collected fuel and hold therefore the potential for addressing questions of fuel selection and woodland exploitation by prehistoric societies (Shackleton & Prins 1992; Smart & Hoffman 1988; Western 1971). It has also been argued, based on the comparative analysis of ethnographic case studies, that fuel collection forms an integral part of the subsistence practices observed at the settlement level, thus being subject to a similar set of social constraints and practical considerations as, for example, food procurement and consumption (Asouti & Austin in press). Taken together, these diverse perspectives on the formation of archaeological wood-charcoal assemblages underline the dynamic nature of the material and demonstrate the multiple avenues that exist for its interpretation.

As with any other class of archaeological material, the recognition of the influences that taphonomic processes have exerted on charcoal preservation is of critical importance for gauging the representativeness of a charcoal assemblage in terms of vegetation environments and fuel-exploitation strategies. One way to address taphonomy is by evaluating the duration of activities represented in the archaeological record (i.e. by separating short-lived contexts such as hearths from those representing assemblages accumulated in the long-term such as charcoal scatters in external areas: cf. Chabal *et al*. 1999). However, the context of deposition represents just one of several factors affecting the preservation of wood-charcoal macro-remains. Equally influential are hearth structure and function, culturally-derived practices of discard of fuel debris, and post-depositional conditions. Burning environments are integrally related to hearth structure (covered as opposed to open fireplaces) and function (industrial kilns versus domestic hearths) (March 1992). Additional sources of patterning may present the various cultural contexts conditioning discarding practices and the treatment of fuel debris (e.g. controlled disposal in a spatially-removed area such as a midden as opposed to unstructured discard: Asouti 2003). Post-depositional processes form another factor in need of consideration; charcoal particles deposited in certain sedimentary environments (periodically drying out sediments) or affected by specific post-depositional processes (freeze–thaw, waterlogging, reheating, trampling, etc.) are likely to have been subject to severe mechanical and chemical stresses resulting in substantial loss of charcoal material (Greenlee 1992; Lopinot 1984). These in turn may render impossible the retrieval of any information other than a list of plant taxa, which will invariably be of limited value for vegetation reconstruction and the evaluation of patterns of firewood exploitation.

In this context, my principal methodological aim was to devise specific analytical tools that could (under the conditions described above) address the representativeness of the wood-charcoal assemblages as signifiers of both past vegetation and settlement economy. Following this, attempts at interpretation focused on two main goals:

- To provide a major source of data that could serve as a basis for reconstructing the Neolithic woodland vegetation in the Konya plain.
- To gain some insights into the local strategies for woodland exploitation during the Neolithic.

Sampling and analytical methodologies

Sample selection

Two principal concerns determined the choice of archaeobotanical samples for wood-charcoal analysis: i) to obtain a reliable picture of long-term patterns of fuel procurement and past vegetation; and, ii) to investigate context-related variation in taxon representation and identify potential sources for the charcoal macro-remains retrieved from the different habitation phases of the settlement. The archaeobotanical samples chosen for analysis thus fall into two groups respectively within the 355 priority samples (see also Tables 10.8–9 on CD):

External refuse deposits (48 flotation samples) deriving from various excavation levels in the South Area. They are separated into an 'early' group comprising units from Pre-level XII.D–A and a 'late' one including units from excavation Levels IX–VII. The main concern here has been to maintain the stratigraphic integrity of the assemblages targeted for analysis.

A group of units derived from Building 1 (North Area, generally corresponding to Level VII, 27 flotation samples), plus a set of contexts other than midden deposits (51 flotation samples) from the South Area (see Tables 10.8–9 on CD). The latter include building infills (Buildings 17 & 18, Levels IX & X), accumulation layers associated with penning activities (Levels XI & XII), secondary fills of pits and various domestic features (Levels VII, VIII, IX, X, XI & Pre-XII), charcoal spreads on floors (rake-outs) and occupation debris from floors (Levels VII, IX & X), lime-burning areas and other external surfaces associated with burning activities (Pre-XII), plus a set of open fires located within an external refuse area (Space 115, Level VIII). The overriding principle here has been not so much to follow a temporal sequence of depositional events but rather, as indicated earlier, to investigate context-related variation and attempt to identify particular processes through which charcoal remains were incorporated in the archaeological layers.

Subsampling in the laboratory

A major consideration when sampling for charred-wood remains concerns the size and number of samples that are likely to provide reliable results. Optimal sample size (in the case of wood charcoal the quantity of fragments per sample that should ideally be examined by the charcoal analyst) varies following sample properties and the degree of accuracy required (van der Veen & Fieller 1982). The total number of charcoal fragments to be examined from each sample is also more difficult to establish following some independent criterion (as happens, for example, with animal bone, whereby the analyst knows *a priori* the population of identifiable items based on the occurrence of specific surface features; wood charcoals obviously do not conform to this principle).

Several authors have observed that taxonomic recovery follows an exponential curve: the number of taxa present in a sample rises sharply as the first few charcoal specimens are examined and then gradually settles down as more fragments have been identified (Chabal *et al.* 1999; Keepax 1988, 44; Smart & Hoffman 1988). Keepax (1988, 120–24) has suggested that a minimum number of 100 fragments per sample should be examined, which may actually extend up to 300–400 fragments depending on the diversity observed within the charcoal assemblage. Chabal *et al.* (1999) raise this lower limit to 250 fragments, with 400 to 500 fragments considered as the optimal subsample size per excavated / stratigraphic level.

Provided that results are for the most part replicated across a certain number of samples from each excavated layer, the size of the subsample can be more realistically set to 150 to 250 fragments per sample. It has been observed that the point when recovery curves tend to level off is not solely a function of the number of examined fragments but also depends on the spatial extent of the sample population across the excavated level (Badal-Garcia 1992). Indeed, by maximizing the spatial coverage of sampling it may be possible to compensate for temporary, and for that reason mostly unpredictable, 'levelling-off' sometimes observed in individual recovery curves (Figueiral 1992).

The same principle was applied when subsampling the Çatalhöyük wood-charcoal assemblages: a total number of 150 fragments per sample were examined (each sample corresponding to one excavated unit; when more than one sample per unit was examined, results were averaged before proceeding with further analysis). This number comprised 100 fragments from the >4-mm fraction of the dry-sieved flot (for details on the flotation and sample-processing methodologies see Chapter 7) and a further 50 fragments from the respective >2-mm fraction, in order to trace small-sized woods (shrubs) and twiggy material not likely to be retained in the 4-mm mesh.

The decision to concentrate mainly on the >4-mm fraction was dictated by the need to maximize the taxonomic information obtained from each sample, while at the same time preventing identification biases that might arise from the examination of charcoal fragments retrieved chiefly from smaller size ranges. Such a subsampling strategy did not pose any real problems with the external refuse deposits, the vast majority of which produced wood-charcoal assemblages large enough to guarantee its applicability. In those few instances where this was not the case (i.e. flot charcoal from the 4- and 2-mm fractions did not amount to the requisite number of 150 fragments) counting stopped when both fractions had been examined in their entirety (Sample 4846.2 140 fragments, Sample 4871.9 104 fragments, Sample 5286.7: 72 fragments, Sample 5310.5: 93 fragments and various units from contexts other than external refuse deposits).

With the exception of Sample 4879.5, Sample 5315.2, Sample 5326.3, Sample 5328.3 (midden deposits), Sample 4711.2 (pit fill), Sample 4715.4, Sample 4716.5 (accumulation/penning layers) of the South Area, and Sample 1358.16, Sample 1359.19, Sample 1367.1, Sample 1372.2, Sample 1423.7 (Building 1) of the North Area, no heavy-residue fractions were examined. In all these cases, the decision to include (when available) the heavy residues was mainly driven by the lack of adequate quantities of flot charcoal.

Concerning the external refuse deposits, all the aforementioned units belong to some of the earliest refuse layers excavated in Çatalhöyük, which also presented certain peculiarities regarding sample composition compared to the rest of the sequence (see below, Results section). Examining heavy residues was therefore done in the course of investigating whether these discrepancies in taxon representation could be attributed to variations in preservation conditions that might have affected the frequencies of individual taxa. This decision was based on the observation that many of these samples contained insufficient quantities of wood charcoal in their respective light fractions. It was hence predicted that most of the wood charcoal originally deposited in these contexts would be retrievable from the heavy residues. Therefore, their microscopic examination was in a sense imperative, in order to obtain an adequate picture of sample composition.

However, the rather arbitrary selection of heavy residues for analysis and the ultimate decision not to treat them in any systematic way was essentially a compromise, made necessary for two reasons. Very few heavy-residue fractions from strata later than Level X were made available for analysis in the first place, thus raising the question of comparability of results relating to sample composition between different settlement phases and context types. Second, it was empirically observed that whatever could be gained by this process in terms of monitoring taxon representation within individual samples was in most cases counterbalanced by a disproportionate increase in the numbers of indeterminate fragments. For midden deposits in particular, obtaining a fair picture of sample composition would have required a substantial increase in the number of fragments examined from both the flot and heavy residue fractions, and thus the microscopic examination of fewer assemblages. The choice therefore lay between examining few samples (300 to 400 fragments per sample), and expanding the number of the analyzed samples, with the aim to offset potential biases in taxon representation through maximum sampling coverage of each excavated level. The solution ultimately adopted was to pursue the second alternative.

Microscopic analysis and identification

Depending on their size, charcoal fragments were either hand- or pressure-fractured with a carbon steel

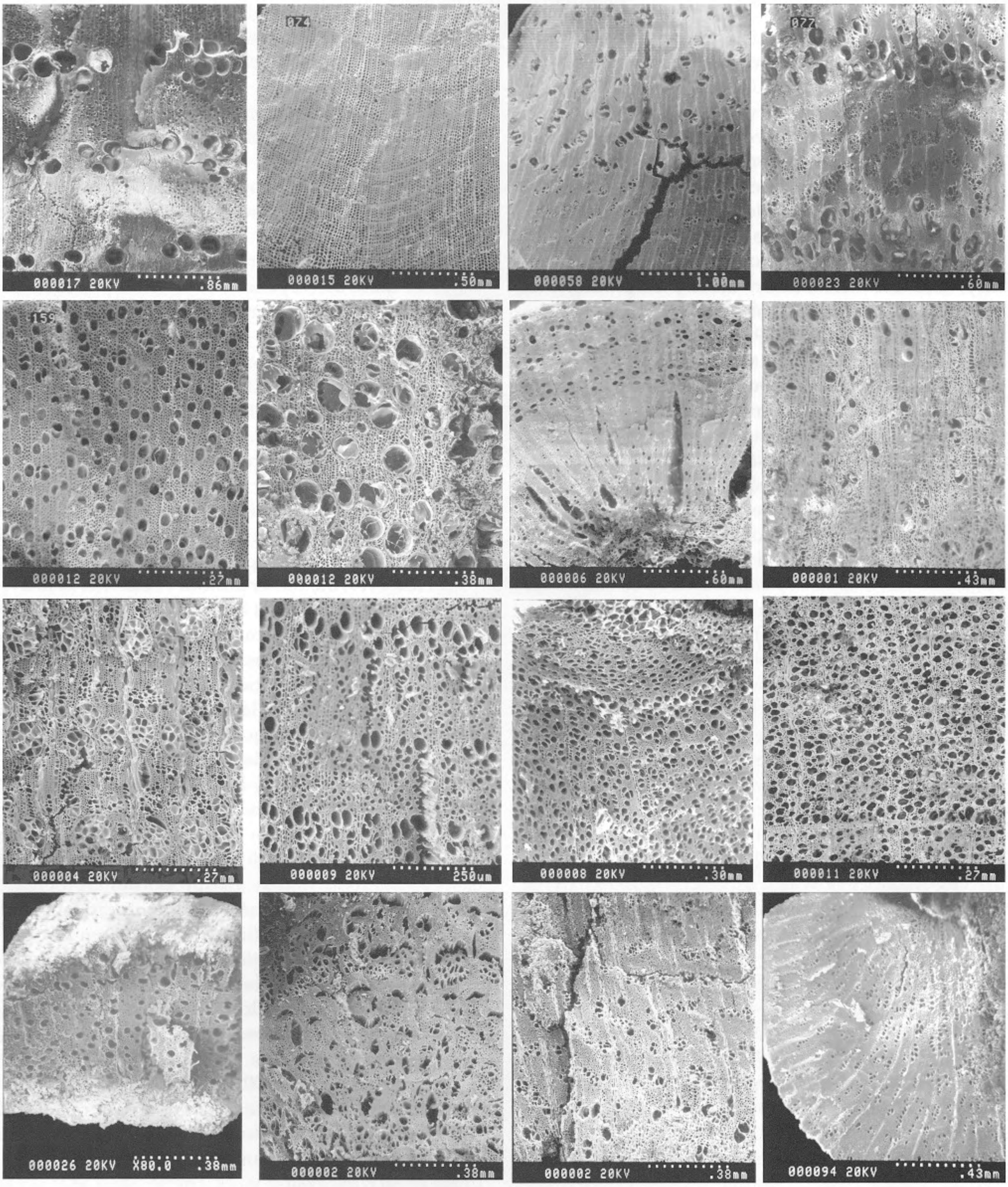

Figure 10.1. *Examples of identified wood-charcoal specimens. From top row (left to right): #17 oak* (Quercus); *#15 juniper* (Juniperus); *#58 hackberry* (Celtis); *#23 elm* (Ulmus); *#12 willow/poplar (Salicaceae); #012 ash* (Fraxinus); *#6 tamarisk* (Tamarix); *#1 fig* (Ficus); *#4 terebinth* (Pistacia); *#9 almond* (Amygdalus); *#8 wild plum* (Prunus); *#11 pear/hawthorn (Maloideae); #26 cornelian cherry/dogwood* (Cornus); *#2 chenopods (Chenopodiaceae); #02 legume shrubs (Fabaceae); #94 wormwood* (Artemisia).

razor blade in order to produce fresh, clean surfaces, whenever possible in all three anatomical planes (transverse, radial longitudinal and tangential) so as to allow a three-dimensional view of their anatomical characters. The resulting pieces were then examined under a high-power, epi-illuminating Olympus BHMJ microscope at magnifications of ×50, ×100, ×200 and ×500. Identifications were made by comparison to charred specimens and thin sections of fresh wood from the C.A. Western wood-reference collection held at the Institute of Archaeology, University College London, plus specimens collected in the field and wood-anatomical descriptions and microphotographs available in Western (1969), Fahn *et al.* (1986), Schweingruber (1990a) and Greguss (1959). The slide reference collection held at the Jodrell Laboratory-Royal Botanic Gardens, Kew was also consulted. Individual specimens were further analyzed and photographed using the Scanning Electron Microscope facilities at the Institute of Archaeology, University College London (see Fig. 10.1).

Table 10.1. *List of all the ligneous taxa recovered from the Neolithic deposits of Çatalhöyük.*

Latin name	**Common English name**	**Turkish name**
Quercus (deciduous)	oak	mese ağacı
Juniperus	juniper	ardıç
Pinus cf. *nigra*	black pine	karaçam
Salicaceae	willow, poplar	söğüt, kavak
Alnus	alder	kızilağaç
Vitex	chaste tree	-
Tamarix	tamarisk	ılgın
Fraxinus	ash	dişbudak ağacı
Platanus	plane tree	çınar ağacı
cf. *Clematis*	clematis	klemetis
cf. *Vitis*?	vine	asma
Ulmaceae	(elm, hackberry)	-
Ulmus	elm	karaağaç
Celtis	hackberry	çitlenbik / çitlambik
Pistacia	terebinth	melengiç, çitlembik
Maloideae	hawthorn, pear	alıç, armut ağacı, elma ağacı
Amygdalus	almond	acı badem ağacı
Prunus	plum, cherry	dag erigi, kiraz ağacı
Rosa	rosebush	gülpüntü / kusburnu
Ficus cf. *carica*	fig	incir ağacı
Acer	maple	akçaağaç
Chenopodiaceae	goosefoot family	kazayağıgiller
Asteraceae	wormwood, sagebrush	papatyagiller
Artemisia	" "	yavşan
Lamiaceae	labiates	ballıbabagiller
Fabaceae	legumes	baklagiller
cf. *Colutea*?	bladder senna	-
cf. *Genista*?	broom	-
Capparis	caper	kebere
Caprifoliaceae	honeysuckle family	hanımeli
Cornus	cornelian cherry, dogwood	kızılcık, kızıl çubuk

In total 27 different taxa were identified in the charcoal assemblages, the latter amounting to 16,003 examined fragments (a complete list of all identified taxa is given in Table 10.1; the anatomical descriptions are presented on CD). Certain wood identifications reported in the context of micromorphological analysis (i.e. *Reaumuria* sp., *Ephedra* sp.: Chapter 19) have not been replicated in the microscopic identifications of charcoal macro-remains[1] It did not become possible to identify any of the examined charcoal fragments to species level on the basis of purely anatomical criteria. Obtaining identifications at the species level is not always possible owing to the similarities in anatomical structure exhibited among members of the same family (e.g. woody legumes-Fabaceae, pear / apple / hawthorn-Maloideae (subfamily of the Rosaceae)) and / or genus (as is the case with the great majority of tree and shrub genera: cf. Hather 2000, 11–12). Variation in anatomical characters can occur amongst specimens belonging to the same taxon, owing to differences in genetic stock, habitats, growing conditions, age and part (bark, stem, twig, branch, root) of individual plants and the exposure to occasional hazards such as fire, frost and pest outbreaks (Dimbleby 1967, 107–8; Wilson & White 1986, 198–9). Furthermore, the small size and the very anatomical structure of certain plant parts preserved by charring (e.g. shrub stems, twigs) may in many cases inhibit botanical identification below the family level (e.g. chenopods-Chenopodiaceae, mints-Lamiaceae).

One solution to these problems is to use wood-anatomical descriptions and comparative collections covering particular geographical regions. However, such collections and descriptions usually include only trunk-wood specimens and are assembled from thin sections of fresh wood. For the purpose of charcoal identification, this can be problematic; characters such as the size and dimensions of pores, vessel elements and rays that may be of diagnostic value in modern specimens of fresh wood (see for example Fahn *et al.* 1986) in charred specimens are either seriously deformed, due to shrinkage and cracking, or missing altogether as is the case with certain types of parenchyma cells. Other features as well, such as spiral thickenings and intervascular pits, can be difficult to locate and describe with any precision, due to variations of lighting on charcoal surfaces during microscopic examination, the excessive presence of mineral precipitates, or if fragments are not studied under sufficiently high magnifications (Western 1969, 112–13 & 115). All these problems can be overcome to some extent by using modern charred specimens as reference material and by examining in detail all three anatomical surfaces (transverse, radial and tangential) at least for the more 'problematic' taxa. Still, botanical identifications below the family or genus level are in most cases unattainable.

Methods of quantification

The abundance of individual taxa within each sample and their presence across samples were plotted by means of fragment counts and presence (i.e. number of samples in which each taxon was present). In order to draw comparisons between different settlement phases, it was necessary to convert both fragment counts and presence scores into percentage values. This was done after excluding from the sums of each sample indeterminate fragments (representing in all cases indeterminate fragments, due to small size or the presence of mineral precipitates and not unidentified taxa). In this way, percentage fragment counts were calculated based on the numbers of total identified fragments for each sample.

Certain taxonomic categories were also excluded from further quantitative analysis (including calculations of diversity index and multivariate analysis; see below). These are the following: Gymnosperms (coniferous wood charcoal too small to identify), Ulmaceae/*Pistacia* (fragments again too small to allow more precise identification as either hackberry/elm-Ulmaceae or terebinth-*Pistacia*), and members of the Anacardiaceae (very small specimens that retained some of the anatomical characters of the pistachio family but otherwise not possible to categorize even under the label of cf. *Pistacia*) and Rosaceae families (comprising fragments too small to be ascribed positively to one of the genera already identified from Rosaceae, i.e. wild plum-*Prunus*, almond-*Amygdalus* and rose-*Rosa*). Their numbers were so low in the assemblages that their omission could not have influenced in any substantive way the plotting of taxon frequencies.

Furthermore, the counts and presence scores of shrubs belonging to wormwoods (Asteraceae, *Artemisia*) and woody legumes (Fabaceae, cf. *Colutea*?, cf. *Genista*?) were combined for the purpose of quantitative analysis in their respective family groups (i.e. Asteraceae and Fabaceae). However, the same principle could not be applied to hackberry (*Celtis*), elm (*Ulmus*) and hackberry/elm (Ulmaceae indet.). Hackberry and elm occupy very different ecological zones (dry woodland and riparian forest respectively). Hackberry was also regularly harvested by the inhabitants of Çatalhöyük for its fruit produce (Chapter 8). It is evident therefore that any combination of the two under the label of Ulmaceae would seriously distort patterns of species representation relating to the reconstruction of woodland habitats and their exploitation. Hence these taxa (*Celtis*, *Ulmus*, Ulmaceae) were retained separate for all further analysis.

Taphonomic analysis: density, fragmentation/preservation and diversity indices

In order to evaluate the taphonomic status of the wood-charcoal assemblages, apart from the standard analytical procedures (fragment counts and presence analysis), some approaches previously untested in the field of charcoal analysis were also applied so as to explore these issues with greater precision than the qualitative statements commonly found in the literature. To this end, two measurements frequently employed in seed archaeobotany (density and diversity) were used, alongside another index (fragmentation/preservation) which was devised to suit the particularities of the material in hand.

Density measurements (expressed as either the number or the total weight of charred items per litre of floated sediment) are widely recognized as a useful means for assessing assumptions of uniform deposition, preservation and recovery rates of charred plant remains (for a detailed discussion of these issues see Miller 1988). For the purpose of this study, total wood charcoal weights were standardized by using as denominator the volume of soil floated from each sampled context (standardized weight values were used as reported in the most recently updated version of the Çatalhöyük archaeobotanical data base; Chapter 7). The outcome of this process was a unique value for each sampled context — a Standardized Weight value (STDW: g/l). Aside from the external refuse deposits (where heavy-residue values were incorporated where available), reliable data on charcoal weights were available for the 4-mm and 2-mm fractions of the dry-sieved flot only and these were used for calculating charcoal densities (no flot volume values were available).

The Fragmentation/Preservation index is a comparison ratio that uses as the norming variable (denominator) the total number of identified fragments per sample, and as numerator the total number of indeterminate fragments from the same sample. In seed archaeobotany, similar indices have been proposed based on the ratio of fragments to whole seeds (fragmentation) and by assigning to individual seeds a numerical value (on a pre-defined scale) consistent with the survival of certain diagnostic features (preservation) (both methodologies were originally developed by Sue Colledge and are presented in detail in Colledge 2001a). In the case of wood charcoal macro-remains, however, it is obviously beyond question to calculate 'whole individuals' as opposed to fragments. Therefore, out of necessity the Fr/Pr index presented here is a compound one, in that it describes in the same unit of measurement the effects of both fragmentation (occurrence of indeterminate fragments due to breakage and reduction of size) and preservation (deformation of diagnostic features caused by thermal degradation and/or the presence of mineral inclusions). This situation accords with the particularities of charcoal taphonomy since these factors are usually interrelated in the ways they affect charcoal preservation (i.e. aside from trampling and other mechanical processes, the concentration of mineral inclusions and thermal degradation may also lead to charcoal fragmentation). However it should be stressed here that such an index, by its very nature, cannot account for variations observed in the representation of individual taxa. Its usefulness lies rather in describing the general preservation status of entire charcoal assemblages and comparing the resulting patterns against qualitative information such as the context type from which the charcoal samples have derived, the associated archaeological features, etc. Values of <0.5 of the Fr/Pr index were taken to indicate low fragmentation and overall good preservation, 0.6–0.9 moderate to high proportions of indeterminate fragments and 1–5 very high proportions of indeterminate fragments.

In order to obtain a numerical value summarizing information on sample diversity, the Shannon-Weaver index was used (Popper 1988). The following formula was used to calculate diversity:

$$H = -\text{sum}\ (N_j / N) \log\ (N_j / N)$$

where N_j is the total number of identified fragments in a given assemblage and N the number of fragments recorded for each taxon in the assemblage. If samples contain many taxa that are evenly distributed, the index values show high diversity. If taxa are few and unevenly distributed, the index values show low diversity. Measuring sample diversity in this way provides a concise numerical description of the broad trends within an assemblage, which may prove very useful for drawing comparisons between different phases/context types and thus distinguishing between specialized and generalized plant assemblages (Popper 1988). The Shannon-Weaver index should, however, always be used in conjunction with abundance and presence data, since two otherwise equal values may represent a different range of taxa but with the same evenness of distribution. Equally, low values may arise in one instance from a limited number of taxa and in another due to their uneven distribution.

Recording of qualitative characters: decayed wood

In order to explore further patterns of taxon representation, an attempt was made to trace some of the qualitative characteristics of the charcoal fragments, particularly the potential for plotting the quantities of decayed/deadwood encountered in the charcoal samples. For this purpose, the presence of fungal hyphae (Boyce 1948, 336–46; Schweingruber 1990b, 192–5; for microscopic examples from the Çatalhöyük material see Fig. 10.2) amongst the larger pieces of charcoal (>4 mm) was routinely recorded during microscopic examination.

Tracing fungal hyphae in charred-wood specimens can be, to a large extent, a fortuitous affair. Due to its weakened internal structure, decayed wood has little chance of surviving the burning process, whereas decay cannot be assumed to have affected in a uniform way the pieces of wood eventually consumed in fire. In addition, wood that is either in the early stages of decay or again very close to final decomposition very rarely maintains visible signs of fungal hyphae. In the first case, hyphae may be very small and difficult to locate, whilst in the latter their sole signs are frequently small boreholes, shrinkage cracks and cell walls in various stages of dissolution, all extremely difficult to identify under the microscope with any degree of certainty, particularly amongst archaeological specimens. It follows that any results produced by recording and quantifying signs of fungal decay should be interpreted with caution and always in relation to the taphonomic history of the assemblage in question.

Due to time limitations, it did not become possible to examine all samples in this detailed fashion (tracing fungal hyphae requires careful examination of both tangential and radial longitudinal planes in the largest surface available, since they are very rarely visible on a transverse section). A number of external refuse deposits from Çatalhöyük (Levels VII–IX) were chosen as a control sample to test for the feasi-

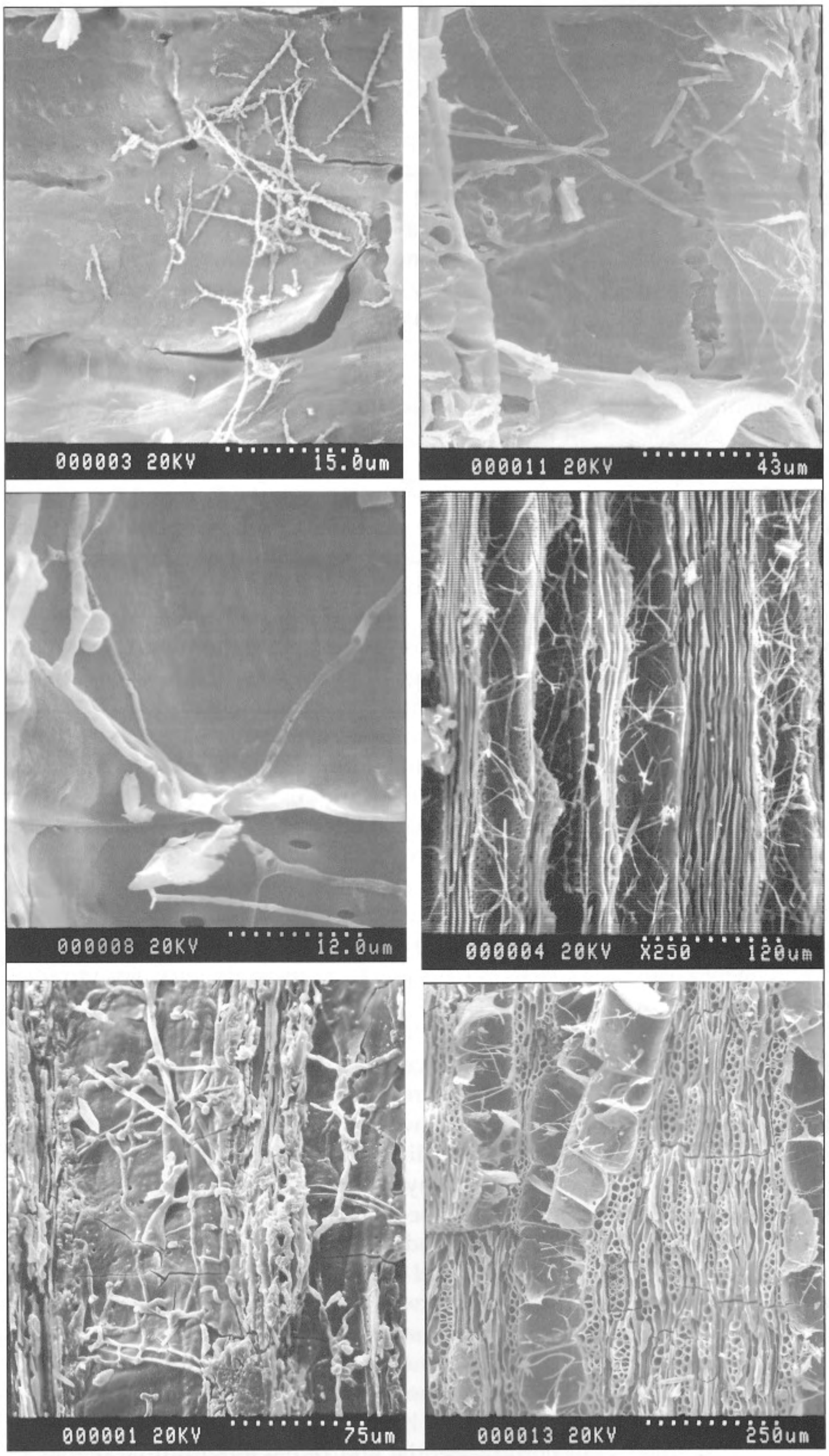

Figure 10.2. *Decayed wood specimens. Top row: #3, #11 ash* (Fraxinus)*; middle row: #8 oak* (Quercus)*, #4 terebinth* (Pistacia)*; bottom row: #1 oak* (Quercus)*, #13 ash* (Fraxinus)*.*

bility of this approach, while samples from other context types and excavation levels were examined in a more cursory way (see below, Results section).

The results of this process were plotted in two ways: as proportions of total decayed/non-decayed wood in each sample and then by groups of taxa (i.e. timber, riverine and fruit trees; shrubs were excluded since the majority of them came from the 2 mm fraction of the dry-sieved flot). Grouping was necessary in order to obtain a clearer picture of decayed charcoal findings and their potential significance. This categorization was based on the following assumptions: it was already known that oak and juniper were the two most important timber taxa in Çatalhöyük (Mellaart 1967; Newton 1996). Secondly, riverine species presented perhaps the sole coherent ecological group, given their strict ecological requirements and lack of overlap with other woodland types. By contrast, certain dryland trees and shrubs (e.g. terebinth, almond, hackberry) could not be considered as representative of individual ecological units (e.g. woodland steppe as opposed to park-woodland), since they could have occurred in more than one woodland types. Hence, the label 'fruit' was considered as a legitimate general descriptive term for dryland woody plants that were presumed to grow further away from the alluvial flats and were also present in the macrobotanical remains as seeds and/or fruit stones. The overall rationale was to trace potential patterns in the proportions of decayed wood that might offer clues to taphonomic (survival rates) and/or behavioural (collection of fallen and/or standing plant parts mainly as

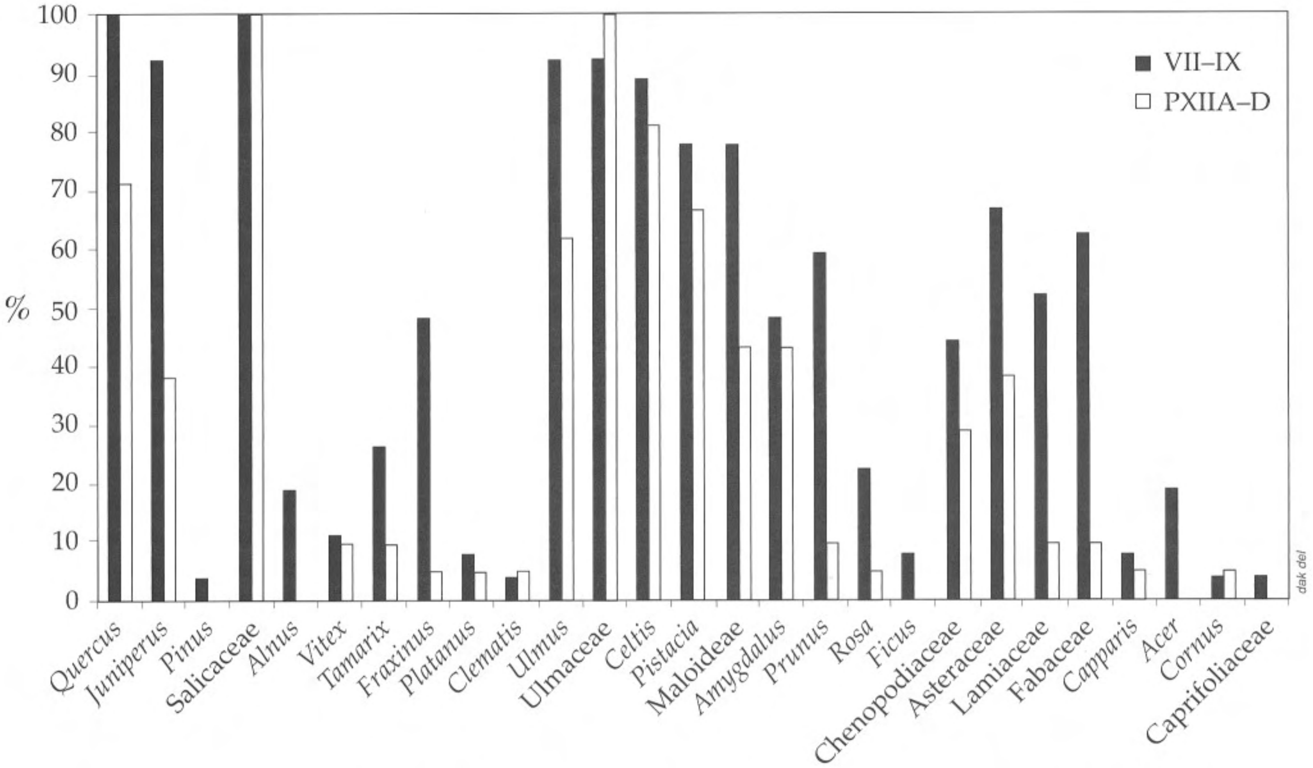

Figure 10.3. *Çatalhöyük-South Area: bar chart showing percentage presence scores (% presence in samples) for all midden samples (no. of samples = 47).*

deadwood, firewood storage, etc.) interpretations. The same grouping system, with the addition of shrubs (i.e. chenopods, legumes, wormwoods and mints likely to have occurred in either more arid and/or saline areas or within woodland openings, and to have been growing and/or gathered in the form of small-sized wood) and Ulmaceae as separate groups was also followed for certain applications of multivariate analysis (see below and Results section).

Statistical analysis: correlation and multivariate statistics

The values obtained from the density, diversity and Fr/Pr indices were compared against each other by means of correlation statistics (Spearman's Rank Correlation Coefficient: Fletcher & Lock 1995, 103–14). In order to investigate further context-related variation and evaluate patterns in taxon representation multivariate statistics were used (correspondence analysis: ter Braak & Šmilauer 1998; Jongman *et al.* 1995; for a discussion of the method in the context of archaeobotanical analysis see Colledge 2001a). Taxa that individually scored less than 10 per cent presence in any given group of samples were excluded from multivariate analysis.

Results

South Area: External refuse (midden) deposits

From the 48 midden units examined in this study, 47 were finally assembled for further quantitative analysis after averaging the results obtained from the split flotation sample of (4836) (Sample 4836.2). For a detailed description of the archaeological attributes of these deposits see Volume 3.

Presence of taxa (Table 10.2; Fig. 10.3)

26 different taxa were recovered from the midden deposits belonging to excavation Levels VII–IX, whilst the Level Pre-XII assemblages gave a number of 22. Of these pine (*Pinus*), alder (*Alnus*), fig (*Ficus*), maple (*Acer*) and members of the honeysuckle family (Caprifoliaceae) were present exclusively in samples from Levels VII–IX.

The percentage presence scores for each set of deposits (see Table 10.2; Fig. 10.3) show that broadly the same range of taxa dominate their assemblages. These are oak (*Quercus*), juniper (*Juniperus*), willow/poplar (*Salicaceae*), elm (*Ulmus*), hackberry (*Celtis*), elm/hackberry (Ulmaceae), terebinth (*Pistacia*) and pear/hawthorn (Maloideae). Almond (*Amygdalus*) is also represented in almost equal proportions in both

Table 10.2. *Çatalhöyük-South Area: summary absolute and percentage fragment counts, presence in samples and percentage presence scores for all taxa found in the charcoal assemblages of the midden samples.*

	Fragment counts				No. of samples in which taxon was present				Fragment counts Pre XII.A–Pre-XIIA(4846)–D				No. of samples in which taxon was present	
	VII–IX	%	**Pre-XII.A–D**	%	**VII–IX**	%	**Pre-XII.A–D**	%	**Pre-XIIA**	%	**Pre-XII.A–D**	%	**Pre-XII.A**	**Pre-XII.A–D**
Quercus	1821	56.92	428	24.70	27	100.0	15	71.4	411	55.47	17	1.71	6	8
Juniperus	136	4.25	10	0.58	25	92.6	8	38.1	3	0.40	7	0.71	2	6
Pinus	1	0.03			1	3.7								
Salicaceae	341	10.66	436	25.16	27	100.0	21	100.0	140	18.89	296	29.84	6	14
Alnus	13	0.41			5	18.5								
Vitex	6	0.19	2	0.12	3	11.1	2	9.5			2	0.20		2
Tamarix	8	0.25	2	0.12	7	25.9	2	9.5			2	0.20		2
Fraxinus	25	0.78	1	0.06	13	48.1	1	4.8	1	0.13			1	
Platanus	2	0.06	2	0.12	2	7.4	1	4.8			2	0.20		1
Clematis	1	0.03	3	0.17	1	3.7	1	4.8			3	0.30		1
Ulmus	91	2.84	76	4.39	25	92.6	13	61.9	3	0.40	73	7.36	2	11
Ulmaceae	134	4.19	473	27.29	25	92.6	21	100.0	65	8.77	408	41.13	6	14
Celtis	174	5.44	170	9.81	24	88.9	17	81.0	80	10.80	90	9.07	6	11
Pistacia	62	1.94	31	1.79	21	77.8	14	66.7	8	1.08	23	2.32	3	10
Maloideae	120	3.75	22	1.27	21	77.8	9	42.9	9	1.21	13	1.31	4	5
Amygdalus	31	0.97	20	1.15	13	48.1	9	42.9			20	2.02		9
Prunus	29	0.91	2	0.12	16	59.3	2	9.5			2	0.20		2
Rosa	9	0.28	1	0.06	6	22.2	1	4.8			1	0.10		1
Ficus	2	0.06			2	7.4								
Chenopodiaceae	20	0.63	7	0.40	12	44.4	6	28.6	1	0.13	6	0.60	1	5
Asteraceae	34	1.06	20	1.15	18	66.7	8	38.1	10	1.35	10	1.01	3	5
Lamiaceae	22	0.69	3	0.17	14	51.9	2	9.5			3	0.30		2
Fabaceae	93	2.91	4	0.23	17	63.0	2	9.5	4	0.54			2	
Capparis	2	0.06	1	0.06	2	7.4	1	4.8	1	0.13			1	
Acer	10	0.31			5	18.5								
Cornus	1	0.03	1	0.06	1	3.7	1	4.8			1	0.10		1
Caprifoliaceae	1	0.03			1	3.7								
Indet.	**851**		**1207**						**309**		**898**			
Total	**4050**		**2940**						**1050**		**1890**			
Total (-Indet.)	**3199**	**100**	**1733**	**100**	**27**	**100**	**21**	**100**	**741**	**100**	**992**	**100**	**6**	**14**

assemblages. Certain taxa such as plane (*Platanus*), alder (*Alnus*), fig (*Ficus*), chaste tree (*Vitex*), clematis (*Clematis*), caper (*Capparis*), maple (*Acer*), black pine (*Pinus* cf. *nigra*) and cornelian cherry/dogwood (*Cornus*) register persistently low presence scores in either group of samples.

Disparities on the other hand are evident in the relative proportions of some of the aforementioned taxa, and the overall representation of ash (*Fraxinus*), wild plum (*Prunus*), rose (*Rosa*) and tamarisk (*Tamarix*). In the Level VII–IX assemblages, both oak (*Quercus*) and willow/poplar (Salicaceae) are present in all samples. By contrast, the presence of *Quercus* is reduced by 30 per cent in the Level Pre-XII units. Similarly, in Levels VII–IX juniper (*Juniperus*), ash (*Fraxinus*), wild plum (*Prunus*), rose (*Rosa*) and (to a lesser extent) tamarisk (*Tamarix*) score very high presence values compared to the Level Pre-XII samples.

The differences observed for elm (*Ulmus*) and hackberry (*Celtis*) are less easy to evaluate, due to the difficulties inherent in separating between the two genera belonging to the same family (Ulmaceae). It is therefore likely that the lower presence scores recorded for elm in the Level Pre-XII samples reflects an identification bias, resulting from the relatively higher occurrence of mineral inclusions in specimens examined from these samples rather than a 'real' difference in sample composition between the two assemblages.

A clear difference emerges, however, when considering the presence scores of shrubs such as chenopods (Chenopodiaceae), wormwoods (Asteraceae), mints (Lamiaceae) and woody legumes (Fabaceae), which are much better represented in the Level VII–IX samples. The trend is constant for all four families and shows a difference in the range of 20 per cent for Chenopodiaceae and Asteraceae, with the gap increasing substantially (roughly 50 per cent) for Fabaceae and Asteraceae.

Fragment counts (Table 10.2, Figs. 10.4–5)

Percentage fragment counts (calculated on the basis of the total number of identified specimens from each assemblage: Table 10.2, Fig. 10.4) replicate at large the results of ubiquity analysis. Thus, the overall picture as to which taxa predominate both assemblages remains broadly the same: oak (*Quercus*), juniper (*Juniperus*), elm (*Ulmus*), hackberry / elm (Ulmaceae), hackberry (*Celtis*), terebinth (*Pistacia*) and pear / hawthorn (Maloideae) are much better represented compared to the rest of the taxa. Almond (*Amygdalus*) values are again almost equal between the two groups of samples, whilst similar trends to those described above are observed for chaste tree (*Vitex*), plane (*Platanus*), clematis (*Clematis*), caper (*Capparis*) and cornelian cherry / dogwood (*Cornus*).

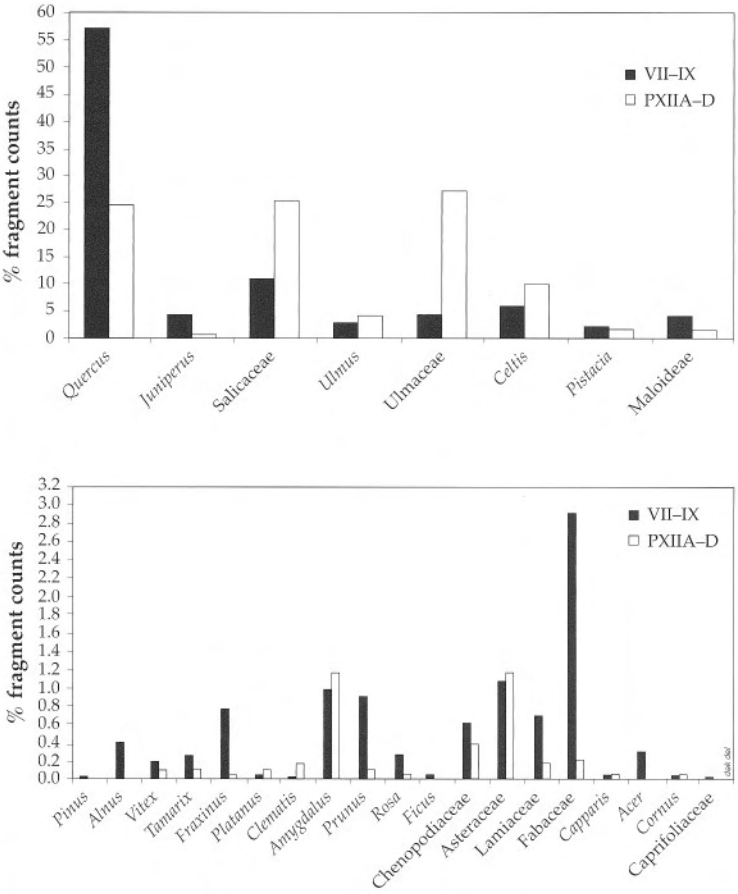

Figure 10.4. *Çatalhöyük-South Area: summary percentage fragment counts for all midden samples (percentages have been calculated after excluding indeterminate fragments from the sums).*

Nevertheless, the comparison of percentage fragment counts with presence scores does reveal some interesting patterns, distinctive for each assemblage. In Levels VII–IX, oak (*Quercus*) is clearly the dominant taxon with a difference of approximately 45 per cent from the second most abundant (Salicaceae). Other co-dominant (by presence) taxa (*Ulmus*, *Celtis*, Ulmaceae, *Pistacia*, Maloideae) score individually values of less than five per cent (hackberry-*Celtis*: 5.44 per cent). Even more depressed are the frequencies of ash (*Fraxinus*), wild plum (*Prunus*), tamarisk (*Tamarix*), chenopods (Chenopodiaceae), wormwoods (Asteraceae) and mints (Lamiaceae) (less than one per cent, with Asteraceae scoring 1.06 per cent). Only marginally better is the representation of woody legumes (Fabaceae) (2.91 per cent). What can be deduced from the evaluation of these low percentages against the respective presence scores is that the abundance values of these taxa are almost evenly distributed across the midden units of Levels VII–IX.

On the other hand, amongst the Level Pre-XII samples oak (*Quercus*), willow / poplar (Salicaceae) and hackberry / elm (Ulmaceae) display almost equal abundance values (~25 per cent). Despite the problems outlined before with separating anatomically between elm and hackberry, it can be inferred that, as a whole, *Celtis* (9.81 per cent) seems to be better represented than *Ulmus* (4.39 per cent). Otherwise, apart from terebinth (*Pistacia*), pear / hawthorn (Maloideae) and wormwoods (Asteraceae) (~1 per cent), all other taxa have abundances of less than one per cent. It would seem therefore that willow / poplar, oak and hackberry / elm are the dominant taxa, with the frequencies of pear / hawthorn, terebinth and almond appearing to be evenly distributed, whilst the remaining taxa appear more or less randomly across samples.

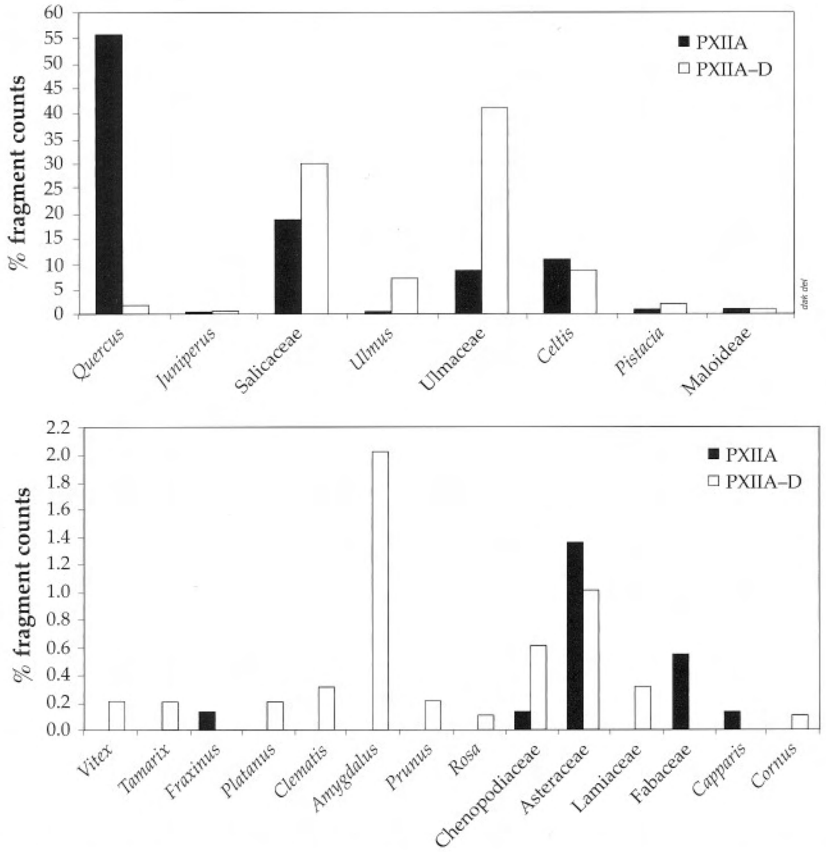

Figure 10.5. *Çatalhöyük-South Area: summary percentage fragment counts for midden samples of excavation Levels Pre-XII.A–Pre-XII.B–D (the phases B–D group includes basal midden unit (4846) of Level Pre-XII.A; percentages have been calculated after excluding indeterminate fragments from the sums).*

However, a closer look at the data (Table 10.2, Fig. 10.5) demonstrates that this first impression is actually inaccurate. Following the abundance values of oak (*Quercus*), I decided to split Level Pre-XII charcoal assemblages in two groups, hence distinguishing between those that gave high oak percentages and those that did not. This distinction also follows closely the subdivisions of the stratigraphic sequence (between Level Pre-XII.A and B; see also Volume 3). From (4846) (the basal unit of the level Pre-XII.A middens) to the bottom of the sequence ((5328), Level Pre-XII.D) oak-charcoal fragments have registered very low frequencies (present in 8 samples out of 14 and never exceeding a maximum of 5 fragments per sample).

What this grouping demonstrates is that Level Pre-XII.A Units (4824) to (4844) actually maintain a picture in many ways similar to that observed for the late (Levels VII–IX) midden samples. Oak (*Quercus*) and willow / poplar (Salicaceae) are present in all samples, with the first being dominant in terms of abundance, whilst hackberry / elm (Ulmaceae) and hackberry (*Celtis*) follow (7 / 7 presence for Ulmaceae and 6 / 7 for *Celtis*; their percentages combined are almost equal to the values recorded for Salicaceae). However, this is where similarities end. *Ulmus* is practically non-existent (2 / 7 presence and a percentage fragment count of just 0.4 per cent) whereas, at the same time, Level Pre-XII.A middens appear to be less taxonomically diverse compared to Levels VII–IX samples.

By contrast, samples categorized within the Level Pre-XII.A (4846)-D group are dominated by hackberry / elm (Ulmaceae) and willow / poplar (Salicaceae). The high percentage of fragments identified as elm (*Ulmus*) in this group suggests that a significant proportion of Ulmaceae may actually stand for elm, in clear contrast to elm's percentages in Pre-XII.A middens. Another major difference between the two groups lies in the number of the taxa recovered: 13 from the Level Pre-XII.A samples and 20 from the Level Pre-XII.A (4846)-D group. It is certainly significant to note that, besides the dominant ones, out of 20 taxa met in the Pre-XII.A (4846)-D group only almond (*Amygdalus*) (9 / 14), oak (*Quercus*) (7 / 14) and juniper (*Juniperus*) (6 / 14) had some sample presence worth mentioning. The rest appeared in very low proportions (1–2 / 14), hence indicating their very random distribution across samples.

It seems therefore that the Level Pre-XII.A samples have fewer and more evenly-distributed taxa, with oak (*Quercus*), willow / poplar (Salicaceae), hackberry (*Celtis*) and hackberry / elm (Ulmaceae) being dominant. On the other hand, the Level Pre-XII.A (4846)-D middens are dominated by Salicaceae, Ulmaceae, *Ulmus* and *Celtis*. With the exception of terebinth (*Pistacia*), pear / hawthorn (Maloideae), almond (*Amygdalus*) and to a much lesser degree oak (*Quercus*) and juniper (*Juniperus*), the overall presence and abundance values of the taxa recovered from this group of middens display an uneven distribution across samples.

To summarize, the quantified charcoal data from the midden sequence of the South Area indicate that during the greater part of the earliest excavated phases (corresponding to Level Pre-XII.D-B also including (4846), the basal unit of Level Pre-XII.A) charcoal assemblages are dominated by riverine taxa, namely willow/poplar (Salicaceae) and elm (*Ulmus*) followed by hackberry (*Celtis*), whilst a substantial part of the assemblage form undifferentiated Ulmaceae (hackberry/elm). Taken together, these taxa account for ~87 per cent of sample composition in the Level Pre-XII midden samples. Furthermore, almond (*Amygdalus*), terebinth (*Pistacia*) and pear/hawthorn (Maloideae) are ubiquitous. On the other hand, oak (*Quercus*) and juniper (*Juniperus*) although present in most samples gave minimal quantities of identified specimens per sample (together 2.42 per cent).

Within the Level Pre-XII.A middens there is some apparent reduction in the overall diversity of the charcoal samples, whilst oak frequencies rise substantially compared to Level Pre-XII.D–B (55.47 per cent). In the samples belonging to Levels VII–IX we can observe the continuation of the predominance of oak from Level Pre-XII.A. There is also a gradual rise in the frequencies and sample presence of juniper. Altogether, the abundance values of oak and juniper account for ~62 per cent of sample composition in the middens of Levels VII–IX. The frequencies of willow/poplar (Salicaceae) remain relatively high through this part of the sequence. One important difference with the Level Pre-XII samples is manifested in the higher presence within Levels VII–IX of other wetland taxa such as ash (*Fraxinus*), chaste tree (*Vitex*), alder (*Alnus*) and tamarisk (*Tamarix*). Together wetland taxa and hackberry (*Celtis*) account for ~25 per cent of sample composition, in clear contrast to their predominance (~87 per cent) in the Level Pre-XII samples. Relatively high proportions are also registered for wild plum (*Prunus*) and shrubs such as woody legumes (Fabaceae), wormwoods (Asteraceae), rose (*Rosa*), honeysuckle family (Caprifoliaceae) and mints (Lamiaceae).

Density, fragmentation/preservation and diversity measurements (Fig. 10.6)

Of the 47 units analyzed, 16 ((1072), (1627), (1066), (1093), (1600), (1638), (1657), (2840), (3773), (3375), (3740), (1649), (1803), (1563), (4824) & (4838)) gave density values well above the mean and the median and another 6 above the median ((1091), (1520), (1523), (2869) & (3314), (4836): see Fig. 10.6). In their great majority, these samples belong to the Levels VII–IX midden deposits, with three units also coming from Level Pre-XII.A, (4824), (4836) and (4838). There are six units with very low charcoal densities, which include all units deriving from Level Pre-XII.B (except (5290)), plus (5326) from Level Pre-XII.D.

Generally, it appears that the late contexts (Levels VII–IX) have denser assemblages compared to the Level Pre-XII deposits, although some variation is evident, especially amongst middens in Spaces 105 (1073), (1506) and 115 (3366) that were associated with activity areas and midden layers accumulated in abandoned building spaces (1642) and (2890). Level Pre-XII.A units also display as a whole relatively high charcoal densities. The opposite is the case with the assemblages from Level Pre-XII.B, which were stratigraphically associated with the locations of external processing areas (i.e. lime burning: Volume 3, Part 2). This negative trend is partly reversed within the remaining samples from Pre-Level XII.C-D (5299), (5310), (5313), (5315), (5317), (5326) and (5328).

Similar patterns are revealed when considering the values obtained for the Fr/Pr index (Fig. 10.6). In total, 13 units registered values above the mean and the median. Of these, following the scale from 0–5, only 7 units fall within the 1–5 class of the Fr/Pr index, indicating high proportions of indeterminate fragments ((4871), (4874), (4875), (4879) & (5286) from Level Pre-XII.B plus (5299) & (5310) from Level Pre-XII.C: see Fig. 10.6). The rest include (2840) (refuse layer associated with obsidian micro-debitage areas in Space 115), (4846) (Level Pre-XII.A) and all the remaining units from Level Pre-XII.B–D, except (5315) and (5328). The latter recorded values equal to and above the median respectively. A few units from Levels VII–IX (1072), (1638), (3314), (3773) and (1642) plus all units from level Pre-XII.A (except (4839) & (4844)) also gave Fr/Pr values above the median.

Concerning diversity (Shannon-Weaver index), there were only two units with very low values compared to the rest of the sequence: (5310) and (5299) from Level Pre-XII.C (Fig. 10.6). These values are also well below the mean and the median for all samples and reflect very low taxonomic diversity. Much higher values (slightly below or equal to the mean and the median) came from the rest of the early units, with (4846) to (5328) (basal deposit of Level Pre-XII.A to Level Pre-XII.D) having rather more taxonomically diverse assemblages compared to Level Pre-XII.A units. The latter display instead a noticeably even distribution of their taxon frequencies across samples (see also above, discussion of taxon presence and fragment counts). Values above the mean and the median were obtained on the contrary from over half of the late midden deposits (Levels VII–IX).

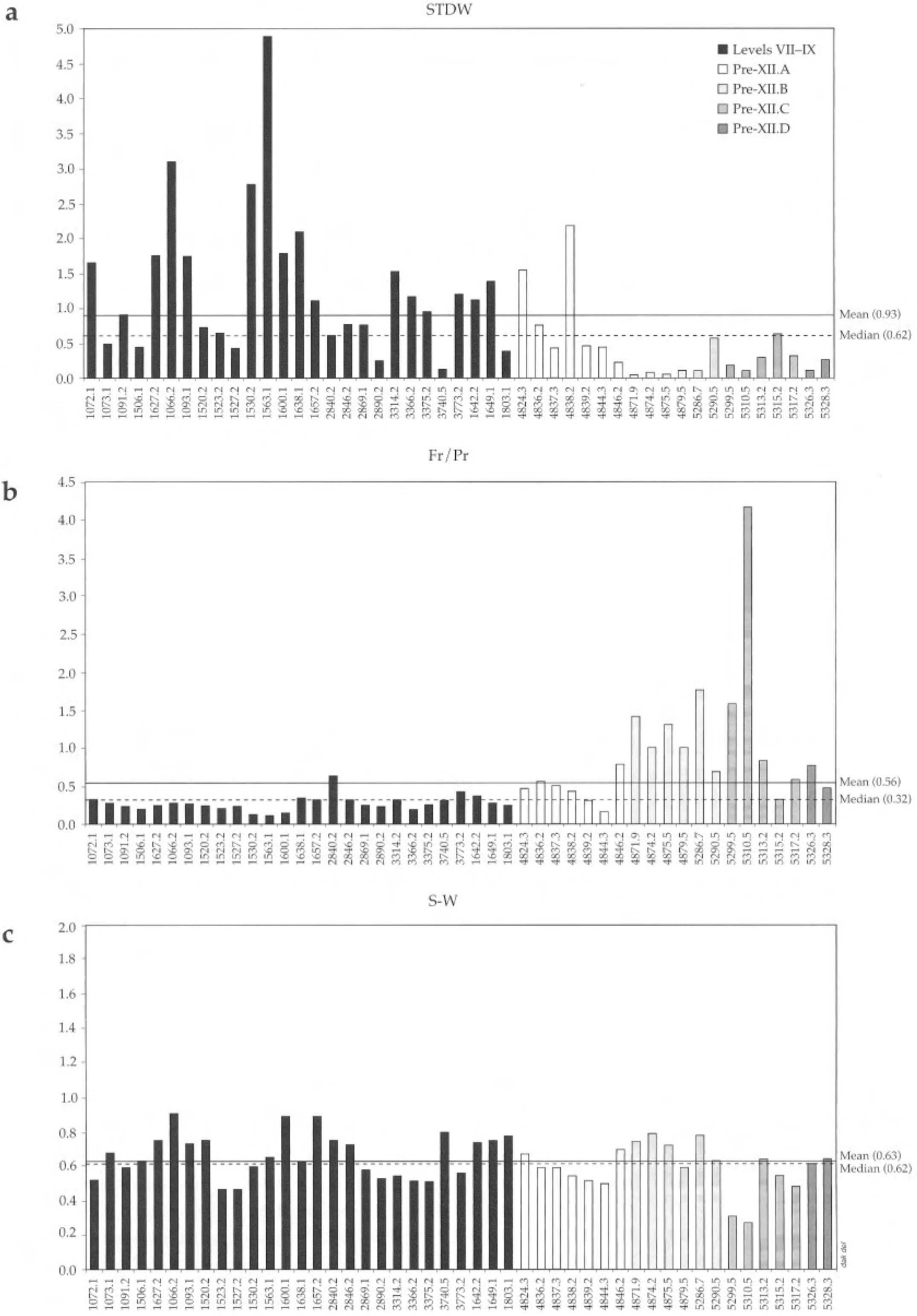

Figure 10.6. *Çatalhöyük-South Area: bar charts showing: a) density (STDW); b) fragmentation/preservation (Fr/Pr); and c) diversity (S-W) values for all midden units (column groups from left to right: Levels VII–IX; Pre-XII.A; Pre-XII.B; Pre-XII.C; Pre-XII.D).*

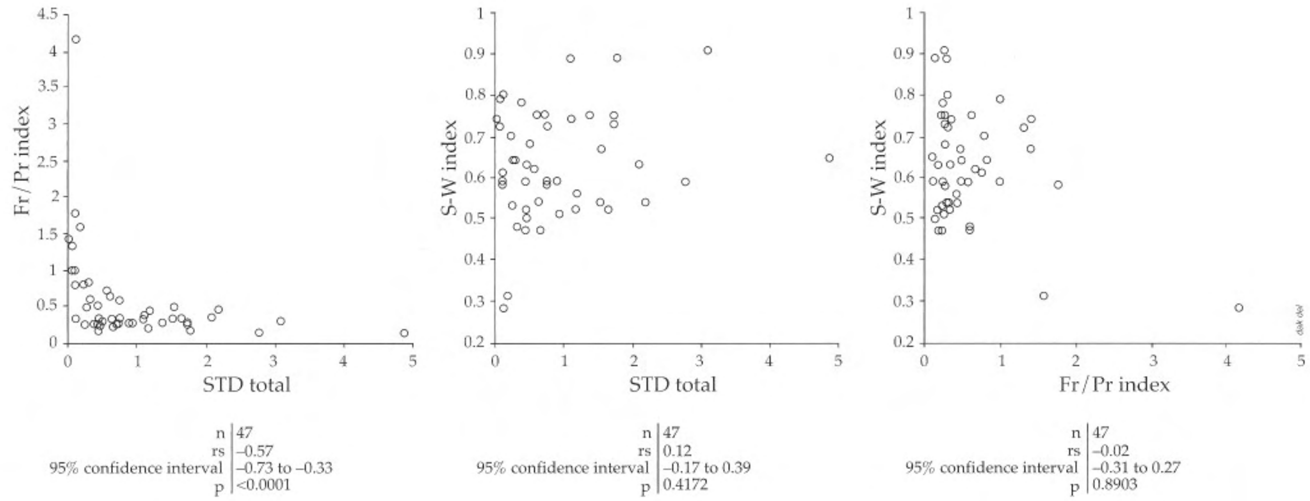

Figure 10.7. *Çatalhöyük-South Area: scatterplots and correlation statistics (Spearman's Rank Correlation Coefficient) of density (STDW), fragmentation/preservation (Fr/Pr index) and diversity (S-W index) values for all midden samples (no. of samples = 47).*

Correlation between density, fragmentation/preservation and diversity measurements (Figs. 10.7–8)
Density (STDW), fragmentation/preservation (Fr/Pr index) and diversity (Shannon-Weaver index) values were compared using Spearman's Rank Correlation Coefficient (STDW:Fr/Pr, STDW:S-W, Fr/Pr:S-W). The first run of the tests (Fig. 10.7) including all 47 samples indicated a significant negative correlation between density-Fr/Pr (*rs* = –0.57, *p* 0.001) and a weak positive correlation between density and diversity values (*rs* = 0.12, *p* 0.042). There was also a weak negative correlation between F/Pr-diversity (*rs* = –0.02, *p* 0.890).

On closer inspection, it becomes evident that the strength of the correlation between density — Fr/Pr indices could be accounted for by the influence of a particular group of outliers. As such were identified (4871), (4874), (4875), (4879) and (5286) (Level Pre-XII.B) and (5299) and (5310) (Level Pre-XII.C). These contexts gave the highest proportions of indeterminate fragments throughout the sequence whilst at the same time displaying overall low charcoal densities (see also Fig. 10.6). The examination of their contextual attributes revealed that for the most part they were associated with external areas used for the production of lime plaster and, presumably, other outdoors activities also involving the use of fire (Volume 3, Part 3). Therefore, charcoal macro-remains deposited in these areas could have undergone several episodes of reheating, trampling and intermixing with other layers, all causing further breakdown of charcoal particles (i.e. effects of post-depositional disturbances).

Apart from this, the very fact that the bulk of charcoal remains deposited in these middens most probably came from open-fire installations (i.e. large shallow pits and/or roughly-prepared clay surfaces; Volume 3) suggests another source of influence on charcoal densities. Their low values could have also been the result of the burning of wood in strongly-oxidizing environments (effects of burning environments and hearth structure). Herein lies an interesting contrast with the much higher charcoal densities recorded from the rest of the midden contexts, which were receiving primarily domestic refuse. Given the lack of openings other than the customary rooftop entrance in the houses of Çatalhöyük, it is reasonable to think that the inadequately-ventilated domestic spaces created those reductive environments that prevented wood charcoals from burning completely and thus enhanced substantially their preservation potential in the archaeological record. This may also explain in part the relatively higher frequencies of small-sized taxa (such as Asteraceae, Lamiaceae and legume shrubs in the majority of the midden samples).

Further evidence for the 'special' status of these midden deposits has been made available through the study of animal bone. Some of the bone was burnt and/or highly fragmented/digested, thus suggesting prolonged periods of exposure and disturbance for the various materials (fuel and bone-processing debris) disposed off in these areas. Exceptional in terms of preservation conditions was

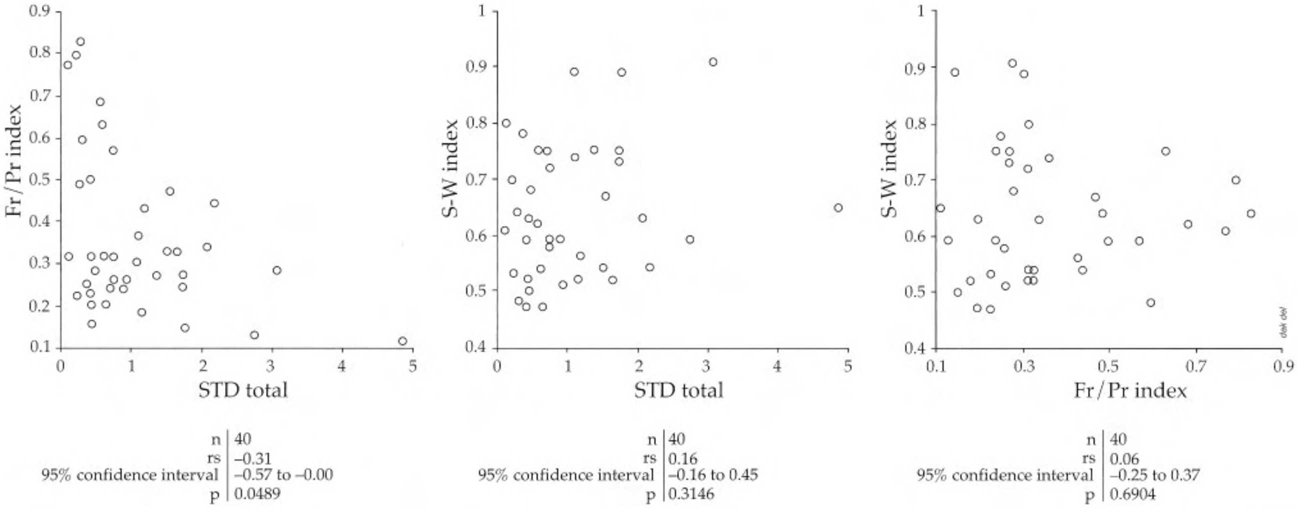

Figure 10.8. *Çatalhöyük-South Area: scatterplots and correlation statistics (Spearman's Rank Correlation Coefficient) of density (STDW), fragmentation/preservation (Fr/Pr index) and diversity (S-W index) values for all midden samples (excluding Fr/Pr outliers from Level Pre-XII.B ((4871), (4874), (4875), (4879), (5286)) and Level Pre-XII.C ((5299), (5310)); no. of samples = 40).*

(5310). The animal bone recovered from this unit has indicated that it contained discreet pockets of material, each characterized by a particular preservation regime (see log in the Finds data base at http://catal.arch.cam.ac.uk/catal/database/scripts/finds/find_sum.idc?Unit=5310). Still, the entire assemblage bore an even, light brown colour which is suggestive of specific post-depositional environments that could have adversely affected the preservation status of wood-charcoal remains (e.g. through the squashing of charcoal particles caused by the accretion of mineral precipitates; the latter was also very evident under the microscope).

These observations offered the necessary archaeological justification for a re-run of the correlation statistics after leaving out the aforementioned units. In other words, it was acknowledged that these units hold distinct plant assemblages, generated for the most part by a relatively narrow range of activities (i.e. lime-plaster production, bone processing, etc.) that exerted their own impact on depositional and post-depositional conditions. They were thus deemed unrepresentative of long-term, widely observed routines of fuel consumption and discard. From the re-run of the statistical tests (40 samples; Fig. 10.8) there emerged a weak positive correlation between density and diversity (*rs* = 0.16, *p* 0.315). In contrast to the earlier results, the negative correlations between density — Fr/Pr and Fr/Pr-diversity (*rs* = –0.31, *p* 0.049 and *rs* = 0.06, *p* 0.690 respectively) were substantially downplayed.

Multivariate analysis (Fig. 10.9)

Figure 10.9 shows the correspondence analysis scatterplots for all midden samples of the South Area. The tight clustering observed on the first principal axis is due to the higher presence of oak (*Quercus*), juniper (*Juniperus*), ash (*Fraxinus*), tamarisk (*Tamarix*) and chenopods (Chenopodiaceae) in the samples from Levels VII–IX (including samples from Level Pre-XII.A that were dominated by oak, indicated by the solid lozenges). Samples belonging to Level Pre-XII.B-D (including the basal midden of Level Pre-XII.A (4846) that was almost devoid of oak) are clearly separated from the Level VII to Pre-XII.A group by virtue of their high values of willow/poplar (Salicaceae), elm (*Ulmus*) and hackberry/elm (Ulmaceae) and their minimal frequencies of oak.

Deadwood (Table 10.3)

In order to explore further some of the qualitative characteristics of the midden assemblages from Levels VII–IX, an attempt was made to assess the potential for plotting the quantities of deadwood encountered in the charred wood remains. The results of this quantification experiment are shown in Table 10.3. First, fragments preserving signs of fungal decay were counted for each sample (>4-mm fraction, major taxa i.e. oak, riverine and fruit trees; shrubs were not considered since most of them were retrieved from the >2-mm fraction). Then the proportions of 'decayed' and 'non-decayed' wood were plotted for each taxonomic group. These results in-

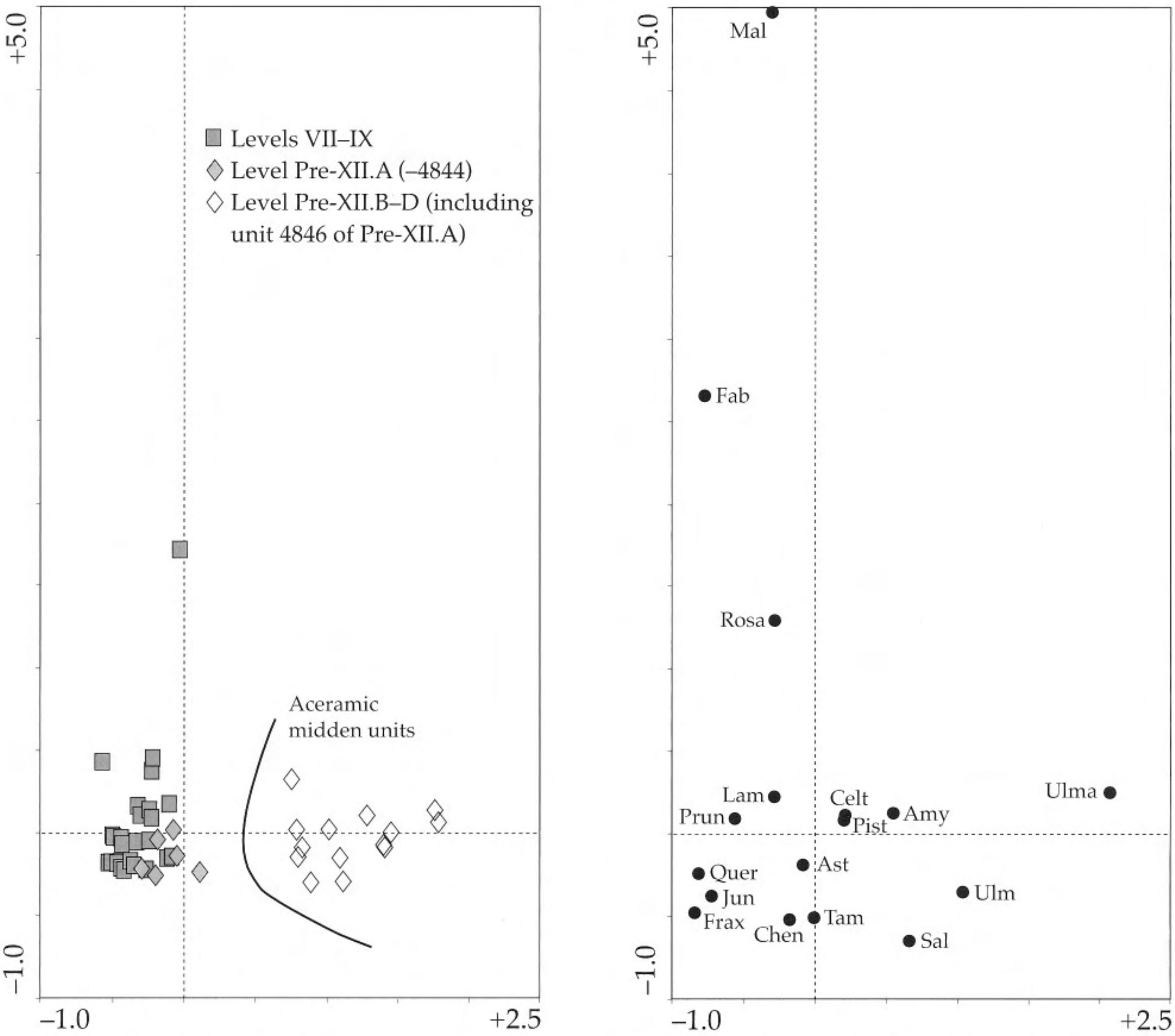

Figure 10.9. *Çatalhöyük-South Area: correspondence analysis scatterplots (left sample plot, right species plot) of all midden samples.*

dicate that the majority of charcoal fragments bearing signs of fungal decay belong to oak (*Quercus*). Oak and riverine taxa comprise the bulk of deadwood specimens retrieved from these samples whilst fruit-producing trees appear in relatively low frequencies. No quantifiable records were kept for the early (Level Pre-XII) deposits. It should be mentioned however that, with the exception of riverine taxa (mainly Salicaceae), very little deadwood appeared to be present in these contexts.

Discussion

The picture emerging from the quantitative analysis of the charcoal assemblages shows clear differences in sample composition between units originating in Levels VII–IX/Pre-XII.A and those from Level Pre-XII.B–D (including (4846) which represents the basal midden layers of Level Pre-XII.A). This is mainly due to the fact that the frequencies of oak (*Quercus*) are very low in the earliest part of the midden sequence (Level Pre-XII.B–D) which is dominated by riverine taxa (willow/poplar, elm) and hackberry. An increase through time in both the sample presence and the percentage fragment counts of juniper (*Juniperus*) is also evident, manifested primarily in the midden samples deriving from Levels VII–IX.

It has also been possible to isolate within Level Pre-XII.B–C a distinct set of contexts, which appear to have received primarily waste generated by specific processing activities, some involving the use of

Table 10.3. *Fragment counts of 'decayed' (deadwood, i.e. charcoal preserving signs of fungal decay) and 'non-decayed' wood from the midden samples of Levels VII–IX (>4-mm fraction of the dry-sieved flot only; group 'riverine' includes Salicaceae,* Fraxinus, Ulmus; *group 'fruit' includes* Celtis, Pistacia, Amygdalus, Prunus, *Maloideae).*

Sample	**1072.1**	**1073.1**	**1091.2**	**1506.1**	**1627.2**	**1066.2**	**1093.1**	**1520.2**	**1523.2**	**1527.2**	**1530.2**	**1600.1**	**1638.1**	**1657.2**
Quercus decayed	20	22	32	37	16	33	25	36	36	23	51	27	75	28
Quercus non-decayed	50	47	42	26	21	14	31	18	44	63	14	20	9	19
Riverine decayed		9	1	14	6	19	18	27	7	1	19	16	7	17
Riverine non-decayed	11	10	14	12		21	7	11	9	2	6	9		5
Fruit decayed		3	6	5	31	5	7	1	4	4	8	17	7	28
Fruit non-decayed	13	9	4	6	25	8	12	7	0	6	3	11	2	3
Total decayed	**20**	**34**	**39**	**55**	**54**	**57**	**50**	**64**	**47**	**28**	**78**	**60**	**89**	**73**
Total non-decayed	**74**	**66**	**61**	**45**	**46**	**43**	**50**	**36**	**53**	**72**	**23**	**40**	**11**	**27**

Sample	**2840.2**	**2846.2**	**2869.1**	**3314.2**	**3366.2**	**3375.2**	**3740.5**	**3773.2**	**2890.2**	**1649.1**	**1803.1**	**1563.1**	**1642.2**
Quercus decayed	24	35	6	34	31	4	46	26	28	26	20	47	42
Quercus non-decayed	25	30	65	38	59	73	24	46	52	31	42	33	23
Riverine decayed	20	10		8	5	1	7	4	3	15	8	8	13
Riverine non-decayed	6	8	17	9	1	7	3	3	7	5	18	1	8
Fruit decayed	10	9	1	3	4		11	9	3	15	3	3	9
Fruit non-decayed	16	8	11	8		15	9	12	7	8	9	8	5
Total decayed	**53**	**55**	**7**	**45**	**40**	**5**	**63**	**39**	**34**	**55**	**30**	**58**	**64**
Total n/d	**47**	**45**	**93**	**55**	**60**	**95**	**37**	**61**	**66**	**45**	**70**	**42**	**36**

fire for the production of lime plaster. The taphonomic observations drawn from the charcoal assemblages of these middens also seem to replicate results produced by other lines of evidence (animal bone, excavation records).

The charcoal assemblages originating in Levels VII–IX display on average higher density compared to the middens of the earliest levels. There are two possible interpretations for this: i) differences in charcoal density reflect variations in preservation conditions, particularly between early and late external refuse contexts; and, ii) firewood was more intensively exploited in the occupation phases represented by excavation Levels VII–IX and Pre-XII.A, than during the timespan represented by Level Pre-XII.B–D.

At first glance, an answer favouring the first alternative would seem very plausible. Early deposits as a whole have provided enough evidence to suggest that preservation conditions may have influenced in various ways charcoal density (e.g. due to their higher clay content). However, it has not been possible to establish a strong negative correlation between density and Fr/Pr values. There seems to be no good reason to conclude that midden units displaying overall lower charcoal densities have been affected by taphonomic parameters to the extent that they may stand for a biased picture of the intensity of fuel use. One possible objection to this argument could be that the relatively raised density values recorded for the early levels (Level Pre-XII.B–D, excluding the Fr/Pr outliers) may be due to the distorting effects of mineral precipitates on total charcoal weights. However, any such effects would have worked both ways: although mineral inclusions may have had some impact on density values, by the same token they could also equally influenced (perhaps more decisively than any other factor) the values obtained for the Fr/Pr index. Most of the indeterminate fragments from the Level Pre-XII.B–D units were due to the presence, in varying degrees, of mineral inclusions.

Concerning taxon representation, another point to be emphasized here is that although differences in preservation conditions do exist between Levels VII–IX and Pre-XII.A deposits as a whole (the latter having a much higher clay content) both the presence scores and the percentage fragment counts of oak (*Quercus*) are very similar between the two groups of samples. In the same vein, if one should view taxon representation primarily as a function of preservation conditions, there is then no real justification for 'light' (and thus more amenable to the destructive effects of thermal degradation and post-depositional mineral build-up) woods such as willow / poplar (Salicaceae), to be dominant in the Level Pre-XII.B–D midden samples that have given significantly lower charcoal densities compared to Levels VII–IX.

Taken together, these arguments appear to cast doubt upon a hypothesis that would hold post-depositional factors as the main determinant for the differences (both inter- and intra-level) observed in charcoal densities and sample composition. It should be stressed furthermore, that there is a very weak correlation between Fr / Pr and diversity values. In other words, it has been possible to establish independently and with some degree of reliability that these refuse deposits represent 'generalized' plant assemblages (*sensu* Popper 1988) containing fuel debris accumulated in the long term, and have been subject to broadly the same range of post-depositional alterations. It was also demonstrated through the same methodology that 'specialized' assemblages (such as those identified in Level Pre-XII.B–C) bear the unmistakable signs of distinctive taphonomic processes directly related to either specific post-depositional regimes (5310) or the particular types of activities and discarding routines that lead to the creation of these deposits in the first place ((4871), (4874), (4875), (4879), (5286) & (5299)).

It seems therefore that, despite the somewhat unbalanced nature of the data set (the early midden contexts are overall under-represented compared to the post-7000 cal BC), when all the different lines of evidence (botanical, contextual and stratigraphic) are brought together there is a relatively strong case to argue that 'more' firewood was exploited during the later (post-7000 cal BC) phases of the settlement. Some insights were also gained concerning possible variations in fuel consumption, particularly within the late phases where quantified data on the relative abundances of different types of deadwood were available. In these it appears that a relatively large proportion of oak and riverine species wood consumed in fires could be classified as 'deadwood'. The taxonomic information available from the Level Pre-XII.B–D samples of the settlement suggests that, generally speaking, at that time firewood collection concentrated on a relatively narrow range of species (mainly willow / poplar, elm and hackberry).

Comparison with non-midden contexts from the South and North Areas

A somewhat different approach was followed in the analysis of charcoal data from context types other than the midden deposits described in the previous sections. As outlined in the introduction, the main idea on the basis of which this suite of analytical methodologies developed was to explore their potential for evaluating in some objective manner the impact of source and context on taxon representation. In this sense, I did not necessarily seek to tease out inter- and intra-level relationships in taxon representation that would be valid for the entire sequence in what concerns particular context types (e.g. fire installations). Such an undertaking would require a very large sample size, covering all excavation levels, in order to be able to account, to some degree at least, for the enormous variation in preservation conditions normally expected from charcoal assemblages of this sort (cf. Chabal *et al.* 1999).

With this purpose in mind, the analysis focused on two main themes: i) a descriptive stage, aiming at identifying 'trends' in taxon representation that could be broadly characteristic of particular context groups; and, ii) inasmuch as such trends could be established, to evaluate them by comparison to the broader temporal picture provided by the analysis of the midden assemblages, and also the available archaeological evidence.

At a practical level, the fact that each context type should be treated on its own meant that certain methodologies tested in the analysis of midden deposits were no longer applicable (i.e. ubiquity analysis and correlation statistics) owing to the small sample size. Instead, other analytical tools such as fragment counts and multivariate statistics were considered as better suited to describe sample composition and uncover any latent patterning in these data sets. Density, diversity and fragmentation / preservation measurements were similarly used in a descriptive manner, in order to see whether any broad trends would emerge which could be identified with particular sets of contexts.

Non-midden contexts of the South Area

Presence of taxa

In total, 23 different taxa were identified in these samples. Compared to the midden deposits certain taxa were absent. These included pine (*Pinus*), alder (*Alnus*), plane (*Platanus*) and fig (*Ficus*). One fragment closely resembling vine (*Vitis* a taxon not encountered in midden deposits) was also recovered from (4821).

Fragment counts (Tables 10.4a–c & 12.7, Figs. 10.10–12)

The first step was to plot in a summary form the absolute fragment counts obtained from each context type (the data for each sample are listed in Ta-

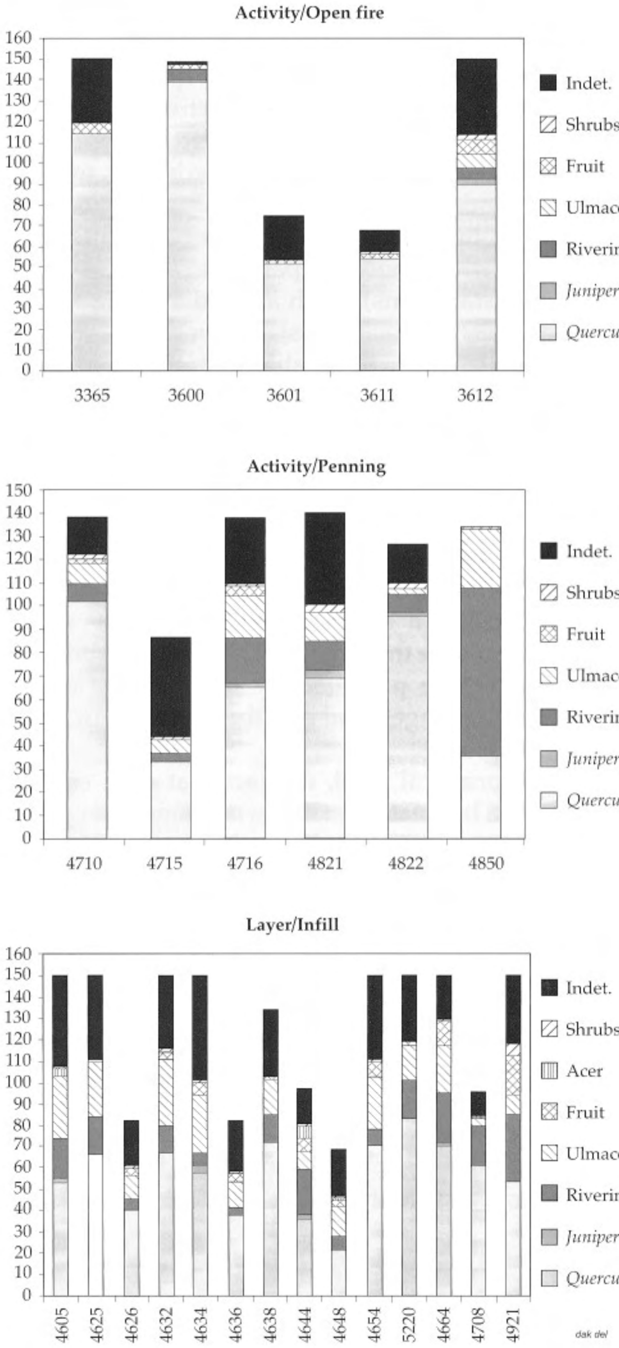

Figure 10.10. *Çatalhöyük-South Area: absolute fragment counts for samples deriving from open-fire, penning and building-infill contexts.*

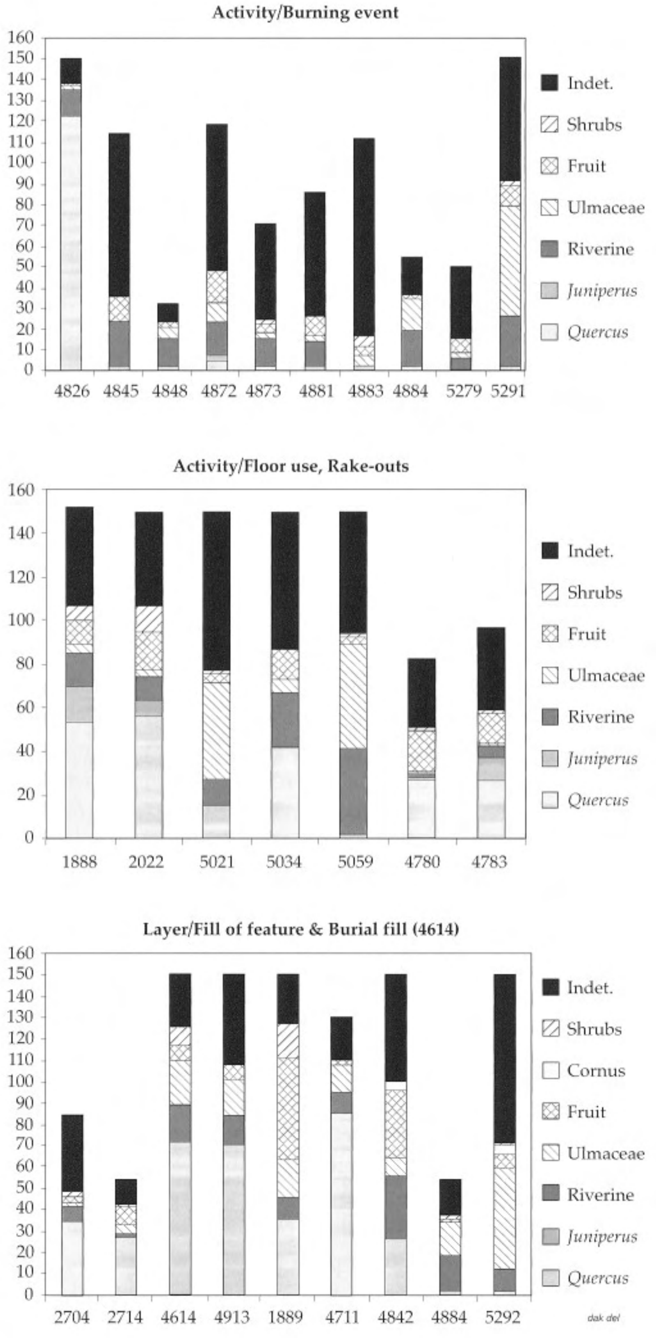

Figure 10.11. *Çatalhöyük-South Area: absolute fragment counts for samples deriving from burning events, floor-use/rake-out deposits and feature fills.*

bles 10.4a–c). For the sake of clarity, individual contexts were grouped according to the type of the main depositional process identified during excavation (see full list of contexts in Table 10.8 on CD). Thus, building infill layers have been separated from the secondary fills of features, but no similar distinction was drawn amongst the latter (e.g. 'oven' as opposed to pit fills). For the same reasons some categorization was also necessary in order to describe general trends in taxon abundance. For this purpose individual taxa were grouped according to either their assumed primary uses (e.g. fruit trees based on

Table 10.4a. *Çatalhöyük-South Area: absolute fragment counts for non-midden samples (units have been grouped according to context type).*

Layer/fill of feature & burial fill (4614)

Sample	**2704.5**	**2714.2**	**4614.3**	**4913.2**	**1889.4**	**4711.2**	**4842.2**	**4884.2**	**5292.3**
Quercus	35	27	72	70	36	85	26	1	2
Salicaceae	4		9	12	6	9	28	17	
Vitex	1	1					2		
Tamarix								1	
Fraxinus				2		1			
Ulmus	2	1	8		4				10
Ulmaceae	1	4	21	17	17	13	9	15	48
Celtis	1	3	5	4	5		21		6
Anacardiaceae							2		
Pistacia	1	6		1	1		4		
Maloideae				2	42	1	4		
Amygdalus			2			1		2	
Prunus	1								
Rosa	1								
Chenopodiaceae			7				2		
Asteraceae			1						
Lamiaceae				1				1	
Fabaceae	1		1		15		2		
Capparis					1				
Cornus									4
cf. Caprifoliaceae	1								1
Indet.	35	12	24	41	23	20	50	17	79
Total	**84**	**54**	**150**	**150**	**150**	**130**	**150**	**54**	**150**

Activity-floor use/rake-out

Sample	**1888.2**	**2022.2**	**5021.29**	**5034.2**	**5059.2**	**4780.2**	**4783.2**
Quercus	54	56	15	42	2	27	37
Juniperus	16	7				1	
Salicaceae	12	9	3	25	26	2	6
Tamarix	1						
Fraxinus	2	1					
cf. *Clematis*			1				
Ulmus	1	1	8		13		
Ulmaceae	3	3	45	6	48	1	1
Celtis	2	8	2	1	4	15	13
Anacardiaceae							1
Pistacia	1	7	1			4	1
Maloideae	7	3	1	12			
Rosaceae				1			
Prunus	1						
Lamiaceae		5					
Fabaceae	7	5				1	1
Capparis		1					
cf. Caprifoliaceae		1					
Indet.	45	43	74	63	57	32	38
Total	**152**	**150**	**150**	**150**	**150**	**83**	**98**

their presence in the macrobotanical record as seeds and/or fruits) or, as is the case with riverine taxa, by habitat preference. The remaining taxa (with the exception of Fabaceae, Lamiaceae, *Capparis*, Chenopodiaceae and Asteraceae, which have been classified as 'shrubs') were quantified individually.

The results of this procedure are shown in Tables 10.4a–c and Figures 10.10–11. Some interesting differentiations between context types are evident. Open fires (a set of hearth deposits excavated in the open area represented by Space 115: see Volume 3, Part 2) have very high proportions of oak (*Quercus*). A similar pattern, although somewhat downplayed by the increased frequency of riverine taxa (mainly willow/poplar - Salicaceae), Ulmaceae and hackberry (*Celtis*) is evident for the samples deriving from the accumulation/penning layers of Spaces 198, 199 (Level XII — layers identified as penning deposits based on the excavation, soil micromorphology and bone evidence). The penning samples are also for the most part directly comparable in terms of sample composition to the assemblages retrieved from

Table 10.4b. *Çatalhöyük-South Area: absolute fragment counts for non-midden units (units have been grouped according to context type).*

Activity/burning events

Sample	**4826.2**	**4845.2**	**4848.2**	**4872.2**	**4873.2**	**4881.2**	**4883.2**	**4884.2**	**5279.2**	**5291.6**
Quercus	122	1	2	4	1	1	1	1		2
Juniperus				3						
Salicaceae	13	22	13	16	13	11		17	6	13
Tamarix								1		1
Fraxinus						2				
Ulmus					1					10
Ulmaceae	2		6	9	3	2	6	15	2	53
Ulmaceae / *Pistacia*		16								
Celtis	1	6	1	13	2	4	2		4	8
Anacardiaceae							1			
Pistacia				2	1	2			3	1
Maloideae		6	1		1		1			1
Amygdalus				1		4		2		
Chenopodiaceae										2
Asteraceae					2		4			
Lamiaceae							1	1		
Indet.	12	79	8	70	46	59	95	17	35	59
Total	**150**	**130**	**31**	**118**	**70**	**85**	**111**	**54**	**50**	**150**

Activity/open fire (Space 115)

Sample	**3365.6**	**3600.2**	**3601.2**	**3611.2**	**3612.2**
Quercus	114	138	52	54	90
Juniperus		1			2
Salicaceae		3			6
Ulmus		2			
Ulmaceae		1			6
Celtis	5		1	1	6
Anacardiaceae		2			
Maloideae		2			
Amygdalus				1	1
Chenopodiaceae					2
Indet.	31	1	21	11	37
Total	**150**	**150**	**74**	**67**	**150**

the infill deposits of Spaces 170, 182 (Building 17) and 171, 172 (Building 18) (infill layers deliberately deposited in the course of building demolition). Higher frequencies of fruit taxa were recorded for (4921) (the upper room fill layers in Space 182) and (4664) (infill placed inside a plastered bin in Building 18) (for further details on the description of individual contexts see Volume 3, Part 2).

Contrasting patterns seem to present the external burning deposits and the rake-out layers (see Table 10.4a–b; Fig. 10.11). The latter, although still maintaining large quantities of oak (*Quercus*) (except (5059) & (5021)), display much higher frequencies for taxa otherwise recorded in relatively low numbers, such as juniper (*Juniperus*) ((1888) & (2022)), fruit trees - Maloideae ((1888), (2022) & (5034)), *Celtis* ((2022), (4780) & (4783)), *Pistacia* ((2022) & (4780)) and shrubs ((1888) and (2022)). These units derive from non-midden contexts in Levels VII ((1888) & (2022)), IX ((5021), (5034) & (5059)) and X ((4780) & (4783) and most likely represent spreads of hearth-derived debris in activity areas). On the other hand (with the exception of (4826) the burning episode sealing the midden sequence of Level Pre-XII.A), the burning events of Level Pre-XII.A ((4845) & (4848)) and several units from Level Pre-XII.B (lime burning (4872) & (4881), burnt layers (4873) & (4883) and external clay surfaces (5279) and (5291)) have given negligible quantities of oak (*Quercus*). Of these, the burnt layers of Level Pre-XII.B held assemblages that included all the major fruit taxa present in the Çatalhöyük sequence (*Celtis*, *Pistacia*, *Amygdalus*, Maloideae).

The feature fills (Table 10.4a, Fig. 10.11) lie somewhere in between the context types discussed so far. (2704) and (2714) (fire installation F.96, Space 112), (4614) (burial fill, Space 163), (4913) (pit fill, Space 173) and (4711) (pit fill, Space 171) are similar to the infill layers, penning areas and open fires in that they are dominated by oak (*Quercus*). (1889) stands out, due to the predominance of fruit (mainly Maloideae, followed by *Celtis* and *Pistacia*) and shrub

Table 10.4c. *Çatalhöyük-South Area: absolute fragment counts for non-midden units (units have been grouped according to context type).*

Layer/infill

Sample	**4605.2**	**4625.1**	**4626.1**	**4632.1**	**4634.1**	**4636.1**	**4638.1**	**4644.1**	**4648.1**	**4654.1**	**5220.1**	**4664.3**	**4708.4**	**4921.2**
Quercus	53	66	40	67	58	38	72	36	21	70	83	70	60	54
Juniperus	2				2			1				1	1	
Salicaceae	12	15	4	9	5	3	10	22	7	6	18	11	17	25
Tamarix		1					1							
Fraxinus					1		2					12		
cf. *Clematis*		1												
Ulmus	7	1	1	3	1					2		1	1	6
Ulmaceae	29	25	11	32	27	13	16	9	14	25	16	22	4	9
Celtis	1		3	1	3	2	1	1	1	3	1	3		11
Anacardiaceae	1			1				1						
Pistacia					1	1			1	2	1		1	6
Maloideae		1			1							7		1
Amygdalus	1				1		1	4				1		
Prunus				1										
Chenopodiaceae			1	1				5	1					3
Asteraceae				1					1	1				
Lamiaceae								1				1		2
Fabaceae	1				1					1				1
Acer										1				
Indet.	43	40	22	34	49	25	31	17	22	39	31	21	11	32
Total	**150**	**150**	**82**	**150**	**150**	**82**	**134**	**97**	**68**	**150**	**150**	**150**	**95**	**150**

Activity/penning

Sample	**4710.4**	**4715.4**	**4716.4**	**4716.5**	**4821.3**	**4822.4**	**4850.4**
Quercus	101	33	70	60	69	96	35
Juniperus			1		3	1	
Salicaceae	9	4	16	18	11	8	70
cf. *Vitis*					1		
Ulmus			2	3	1		2
Ulmaceae	8	6	7	28	12	2	26
Celtis	2		9	1	3	3	
Pistacia							1
Chenopodiaceae		1		1			
Lamiaceae		1					
Indet.	30	16	45	39	28	40	16
Total	**150**	**61**	**150**	**150**	**128**	**150**	**150**

taxa. With the exception of (4842) (pit fill in Space 181 Level Pre-XII.A) which contained a balanced mixture of oak/riverine and fruit/shrub taxa (Salicaceae, *Ulmus*, *Vitex*, *Celtis*, *Pistacia*, Maloideae, Chenopodiaceae, Fabaceae), the remaining non-midden units from Pre-XII gave almost no oak charcoal at all ((4883), (4884) & (5292), Level Pre-XII.B). The retrieval of 4 fragments of cornelian cherry/dogwood (*Cornus*) from the fill (5292) of a shallow scoop associated with burning activities is interesting. *Cornus* is very rare throughout the sequence (midden deposits included) and this is its highest-recorded frequency within a single sample.

Having identified these patterns, the next step was to summarize all the available information in a single unit of measurement for every context type. To this end, the percentage fragment counts of all taxa were calculated for each context type. The groups of riverine taxa and shrubs were kept in place, since they were either dominated by a particular taxon (riverine-Salicaceae) or comprised different taxa which, taken individually, registered very low abundance values (shrubs: Fabaceae, Lamiaceae, Asteraceae, Chenopodiaceae, *Capparis*, *Rosa*, Caprifoliaceae). Table 10.5 and Figure 10.12 present the outcome of this process. As becomes evident from the inspection of the charts, the highest frequencies for oak (*Quercus*) occur by far among the deposits of the post-7000 cal BC phases: the open fires (Space 115), the infill layers of Buildings 17, 18 and the penning deposits (Spaces 198 & 199). Rake-out and other floor deposits associated with the use of domestic fire installations also registered quite high frequencies of both oak (*Quercus*) and juniper (*Juniperus*). General building infills and penning layers also gave relatively high percentages for willow/poplar (Salicaceae) and low, albeit constant, values for fruit and shrub taxa. Feature fills closely resemble build-

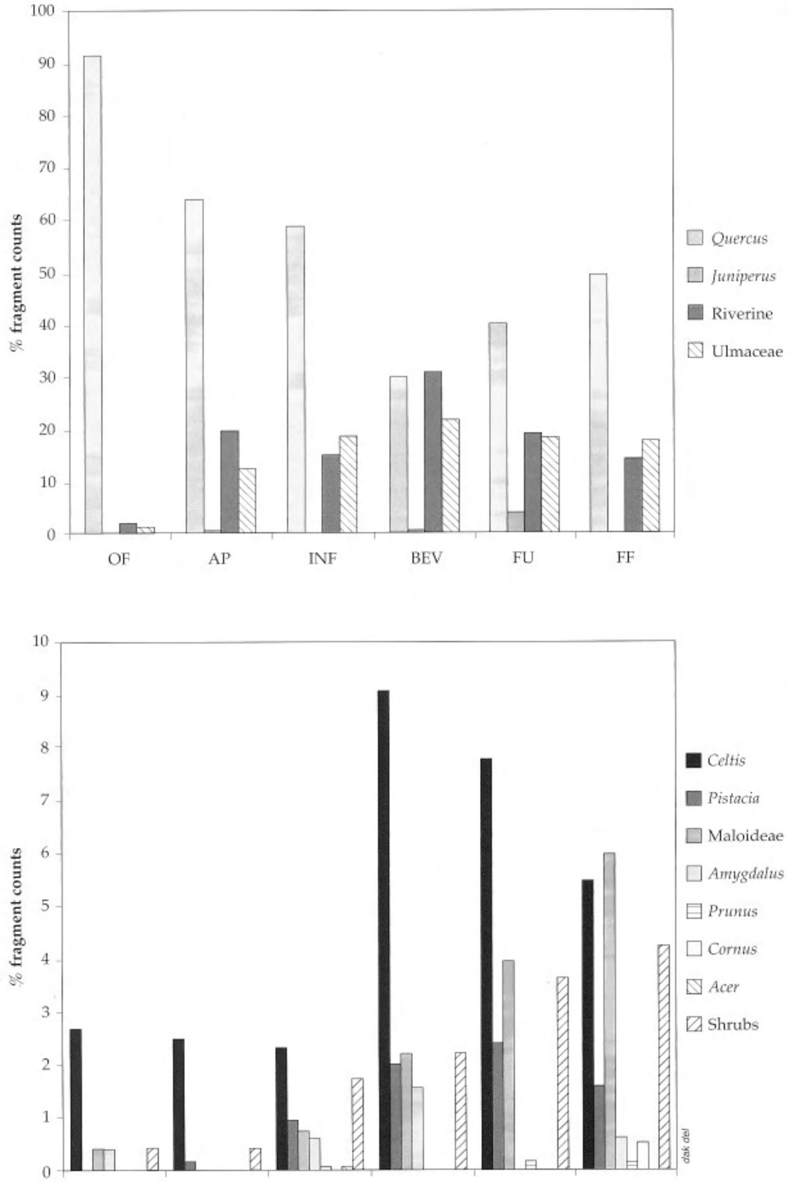

Figure 10.12. *Çatalhöyük-South Area: summary percentage fragment counts for all non-midden units (samples are grouped by context type: OF = open fire; AP = Accumulation/Penning; INF = infill; BEV = burning event; FU = floor use (Rake-out); FF = feature fill).*

ing infills in what concerns the frequency values of oak (*Quercus*), even though they generally display higher abundance values for fruit and shrub taxa. This may reflect the very mixed nature of the deposits in question (an assortment of 'oven' fills and other feature layers). On the other hand, the open fires/burning layers belonging to the Level Pre-XII.B–D strata gave almost no oak fragments at all (with the single exception of (4826)). Finally, fruit and shrub taxa are much better represented within the activity areas of all levels (rake-out units and external burning events) although hackberry (*Celtis*) is more dominant amongst the latter, with rake-out assemblages appearing to be somewhat more diverse.

Density, diversity and fragmentation/preservation measurements (Fig. 10.13)
Building infills and accumulation/penning deposits show the most consistent pattern with low density and Fr/Pr values, which are almost evenly distributed around the median (see Fig. 10.13). Much higher charcoal densities are observed for the open fires of Space 115 (four out of five sampled contexts gave values well above the mean and the median) whereas rake-out units and external burning episodes demonstrate markedly fluctuating values, which is typical of short-term events (compare the very high densities obtained from (5059) & (4826) with the rest of the sampled contexts). High charcoal densities (above the mean and the median) were also obtained from the feature fills associated with fire installations ((1889), (2704) & (2714)).

Both rake-out units and the external burnt deposits (especially the latter) display very high Fr/Pr values. Of the seven units that have registered values in the range of 1–5 of the Fr/Pr index (see Fig. 10.6), four are identified with burning surfaces (including the lime-burning areas) and pits containing related fire debris ((4872), (4881), (5279), (5292) & (4883)), whereas two correspond to burnt layers ((4845) & (4873)). Note here the marked contrast in density values with the open fires of Space 115.

Although diversity measurements, due to the small sample size, should be viewed with caution, they nonetheless indicate some interesting general trends, which are in line with the results produced by the analysis of fragment counts. Thus, in contrast to some accumulation/penning layers ((4710), (4715) & (4822)), the open-fire deposits from Space 115, two burnt layers ((4845) & (4826)) and some fill layers ((4711), (4708) & (5220)) that have registered values well below the mean and the median, the remaining units gave relatively high diversity values. By far the highest diversity show some general burning (4842) and upper

Table 10.5. *Çatalhöyük-South Area: summary absolute and percentage fragment counts for all non-midden samples (samples are grouped according to context type: OF = open fire; AP = activity/penning; INF = building infill; BEV = burning event; FU = Floors use; FF = feature fill).*

	Absolute fragment counts						Percentage fragment counts					
Context type	**OF**	**AP**	**INF**	**BEV**	**FU**	**FF**	**OF**	**AP**	**INF**	**BEV**	**FU**	**FF**
Quercus	448	464	788	135	233	408	91.80	64.00	58.85	29.87	40.24	49.57
Juniperus	3	5	7	3	24		0.61	0.69	0.52	0.66	4.15	
Riverine	11	145	205	139	111	118	2.25	20.00	15.31	30.75	19.17	14.34
Ulmaceae	7	89	252	98	107	145	1.43	12.28	18.82	21.68	18.48	17.62
Celtis	13	18	31	41	45	45	2.66	2.48	2.32	9.07	7.77	5.47
Pistacia		1	13	9	14	13		0.14	0.97	1.99	2.42	1.58
Maloideae	2		10	10	23	49	0.41		0.75	2.21	3.97	5.95
Amygdalus	2		8	7		5	0.41		0.60	1.55		0.61
Prunus			1		1	1			0.07		0.17	0.12
Cornus						4						0.49
Acer			1						0.07			
Shrubs	2	3	23	10	21	35	0.41	0.41	1.72	2.21	3.63	4.25
Indet	**101**	**214**	**417**	**480**	**352**	**301**						
Total (-Indet.)	**488**	**725**	**1339**	**452**	**579**	**823**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

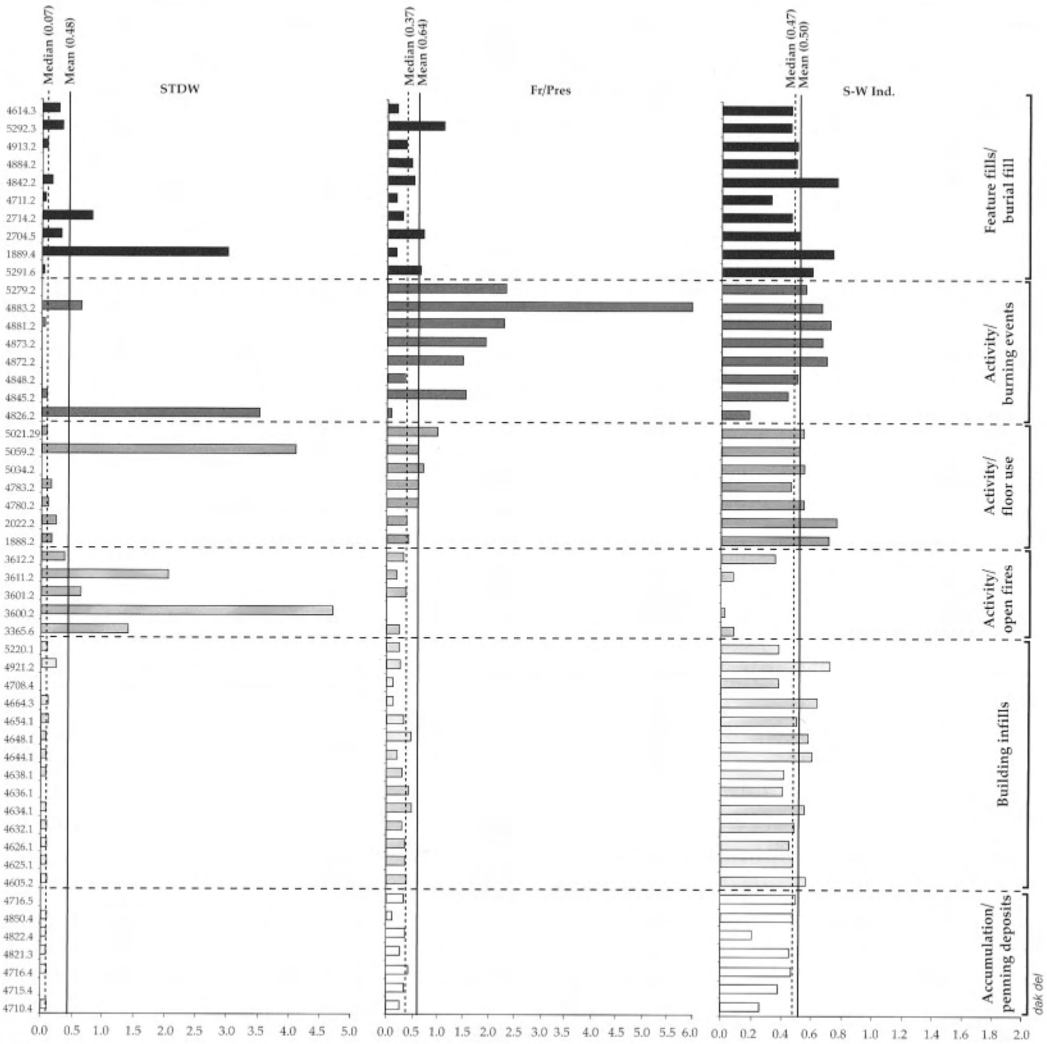

Figure 10.13. *Çatalhöyük-South Area: bar charts showing density (STDW), fragmentation/preservation (Fr/Pr) and diversity (S-W) values for all non-midden units (column groups from top to bottom: feature fills/burial fill; activity/ burning events; activity/floor use (rake-outs); activity/open fires (Space 115); building infills; accumulation/penning deposits).*

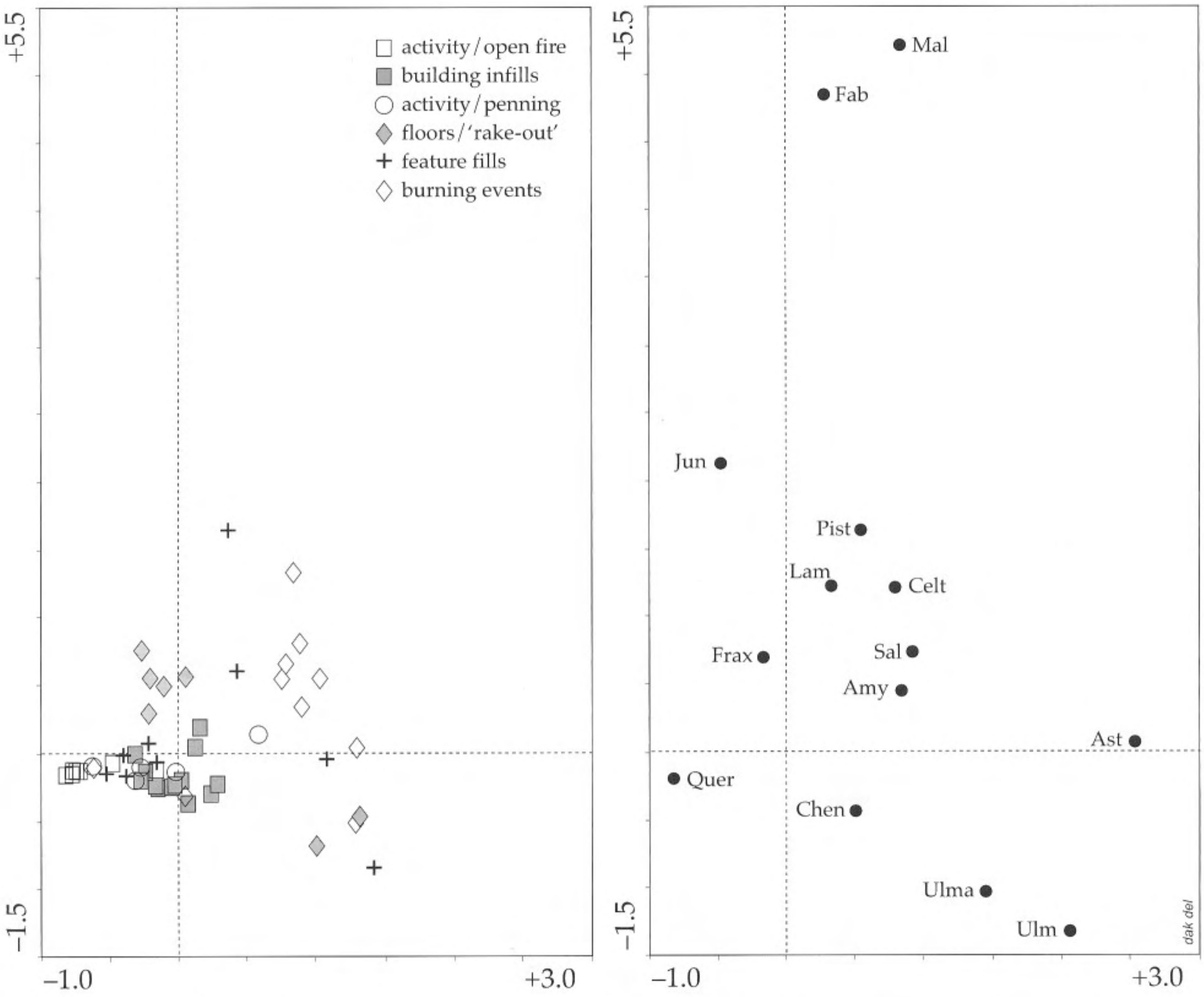

Figure 10.14. *Çatalhöyük-South Area: correspondence analysis scatterplots (left sample plot, right species plot for the same samples) of all non-midden samples.*

infill ((4644), (4654) & (4921)) layers, alongside the fill in Space 117 (1889) and two rake-outs ((1888) & (2022)). High values were also registered for deposits associated with the lime-burning areas ((4872), (4873), (4881) & (4883)).

Multivariate analysis (Fig. 10.14)

Figure 10.14, shows the correspondence analysis scatterplot for all non-midden contexts of the South Area. The first principal axis separates between the assemblages dominated by oak (*Quercus*) (mainly open fires, building infills and accumulation/penning deposits followed by most of the rake-out units; all belonging to post-Level XII layers) and those displaying higher frequencies of riverine, shrub and fruit taxa (all the burning events from the Level Pre-XII strata and a penning layer (4850) particularly rich in willow/poplar - Salicaceae). The second principal axis differentiates the samples deriving from open fires, accumulation/penning and infill deposits from the rake-out units, which overall held more juniper (*Juniperus*), shrubs and fruit taxa (aside from (5059) & (5021) that contained high proportions of Ulmaceae). Finally, as expected, the variable in sample composition feature fills do not demonstrate noticeable patterning.

Discussion

Some interesting temporal patterns emerge from the comparison of non-midden context types with the external refuse deposits discussed in the previous section (compare Figs. 10.9 & 10.14). What the open fires in Space 115, the accumulation/penning layers (Spaces 198 & 199) and the basal infills of Buildings

Table 10.6. *Çatalhöyük-North Area: absolute and percentage fragment counts for all samples examined from Building 1 grouped by building phase (for a detailed discussion of Building 1 phases see Part 3, Volume 3).*

	B1.2		**B1.3**		**B1.4**		**B1.5 A-2**		**B1.E**	
	count	%	**count**	%	**count**	%	**count**	%	**count**	%
Quercus	421	60.58	298	73.58	261	65.09	89	53.29	334	70.46
Juniperus	69	9.93	16	3.95	15	3.74	14	8.38	55	11.60
Salicaceae	50	7.19	64	15.80	77	19.20	34	20.36	7	1.48
Vitex									1	0.21
Tamarix	1	0.14								
Fraxinus	3	0.43			1	0.25				
Platanus					1	0.25				
Ulmus	29	4.17	1	0.25	2	0.50	6	3.59	8	1.69
Ulmaceae	39	5.61	19	4.69	6	1.50	18	10.78	13	2.74
Celtis	20	2.88	4	0.99	4	1.00	5	2.99	9	1.90
Pistacia	6	0.86			5	1.25			14	2.95
Maloideae	2	0.29							2	0.42
Amygdalus	3	0.43							5	1.05
Rosa	3	0.43			1	0.25				
Ficus	3	0.43			5	1.25				
Chenopodiaceae	1	0.14							1	0.21
Asteraceae	5	0.72							4	0.84
Lamiaceae	8	1.15			4	1.00			3	0.63
Fabaceae	28	4.03	2	0.49	11	2.74			12	2.53
Capparis	1	0.14	1	0.25					2	0.42
Caprifoliaceae	2	0.29							2	0.42
Indet.	**236**		**109**		**152**		**35**		**151**	
Total	**931**		**514**		**553**		**202**		**625**	
Total (-Indet.)	**695**	**100.00**	**405**	**100.00**	**401**	**100.00**	**167**	**100.00**	**474**	**100.00**

17, 18 seem to have in common with many midden samples deriving from the same post-Level XII part of the examined sequence is the clear predominance of oak (*Quercus*) in their charcoal samples. It is worth noting here that certain non-midden units (such as rake-out units, upper room fills containing a substantial component of domestic refuse, and 'oven' infills) although still dominated by oak, display overall higher frequencies of fruit and shrub taxa compared to likely reworked deposits such as the majority of building infills. By contrast the external burning events, the majority of which derive from the Level Pre-XII strata, demonstrate very low frequencies of oak.

Very few of all the aforementioned units gave enough charcoal from the >4-mm fraction (i.e. at least 100 fragments) for plotting with some degree of reliability the proportions of decayed wood. One such unit was (3600) (open fires, Space 115), which was very rich in oak charcoal. Of the latter, 50 out of 86 fragments retrieved from the >4-mm fraction bore very clear signs of fungal decay. This trend was also evident amongst the rest of the samples belonging to the same context category ((3601): 3/5 fragments, (3365): 12/16 fragments, (3611): 9/11 fragments). The material from building infills and accumulation/penning layers was also not systematically quantified for the same reasons (overall lack of sufficient fragment numbers from the >4-mm fraction). However, oak (*Quercus*) and willow/poplar (Salicaceae) fragments bearing signs of fungal decay were occasionally spotted in these charcoal samples. Decayed oak wood was not as ubiquitous among samples recovered from other context types (e.g. the burning episode represented by (4826) that gave the highest oak frequencies from all burning layers).

Units that represent major external burning events and activities such as lime burning (Level Pre-XII strata) are also clearly differentiated from the rest of the examined material in what concerns their overall high taxonomic diversity. No domestic contexts similar to those of the post-Level XII levels (e.g. infill layers) were available from the earliest strata in order to compare and evaluate patterns of taxon representation (particularly in relation to fruit and shrub taxa). Still, a comparison of these lime-burning layers to the midden contexts examined from the same early levels (i.e. those identified as 'outliers' due to their high Fr/Pr values) is instructive. Both sets of deposits display similarities in what concerns their taphonomic characteristics (e.g. low density and high Fr/Pr values) and sample composition (a mixture of Salicaceae, *Celtis*, *Pistacia*, *Amygdalus* and various shrubs such as Lamiaceae and Asteraceae). This observation lends additional support to the suggestion that most of the charcoal found in these particular midden samples had originated in the lime-burning fires of Level Pre-XII.

Domestic contexts of the North Area: Building 1

The approach followed with the analysis of the charcoal data from Building 1 is similar to that adopted for the study of the non-midden contexts from the South Area. However, due to the small number of samples made available for analysis, it did not become possible to classify charcoal assemblages according to context type. Instead, the categorization by occupation phase as identified by the excavators (Volume 3, Part 3) was maintained. The general aim was to investigate potential sources of patterning in the archaeobotanical record introduced by shifts in the general use of space throughout the life history of Building 1. In addition, the external deposits served the purpose of tracing possible differences in the types of waste disposed in these areas compared to the midden contexts of the South Area.

Presence of taxa

In total, 20 different taxa were recovered from the 26 charcoal samples examined from Building 1. These include all the major taxa encountered in the South Area (i.e. *Quercus*, *Juniperus*, Salicaceae, *Ulmus*, *Celtis*, Ulmaceae, *Pistacia*, Maloideae and *Amygdalus*) and broadly the same types of shrubs too (*Rosa*, *Capparis*, Fabaceae, Lamiaceae, Asteraceae and Chenopodiaceae). By contrast, certain taxa associated with riverine habitats were absent (*Alnus*, *Clematis*, *Vitis*). Others, such as plane (*Platanus*), ash (*Fraxinus*), tamarisk (*Tamarix*) and chaste tree (*Vitex*) were present in very few samples (one each). Low presence was also observed for chenopods (Chenopodiaceae), fig (*Ficus*) and Caprifoliaceae.

Fragment counts (Table 10.6, Fig. 10.15)

Table 10.6 and Figure 10.15 present in a summary form the absolute and percentage fragment counts for Phases B1.2, B1.3, B1.4 and B1.5A, plus the external deposits (B1.E). Oak (*Quercus*), willow/poplar (Salicaceae) and juniper (*Juniperus*) are by far the commonest taxa. The highest percentages for oak (*Quercus*) are recorded amongst the destruction fills (Phase B1.3) and the external deposits (Phase B1.E). The latter together with Phase B1.2 contexts (main occupation) have also given the most diverse assemblages. At the same time, juniper (*Juniperus*) displays high frequencies within the main occupation phase (B1.2) being practically non-existent in the external areas.

Willow/poplar (Salicaceae - comprising the bulk of the riverine taxa) as well as fruit and shrub taxa show quite a random pattern in the distribution of their frequency values, which could be attributed to the uneven representation of individual context types. On closer inspection, it becomes evident that certain contexts contain very diverse assemblages. These are (1437) (rake-out, B1.2), (1372) (burial fill, B1.2) and (1310) and (1347) (external deposits, B1.E). By contrast, the least diverse samples seem to belong to the destruction horizon (B1.3). Occasionally, some rare taxa are also encountered amongst the phase B1.4 contexts (e.g. *Platanus* in hearth (1386)).

Density, fragmentation/preservation and diversity measurements (Fig. 10.16)

Overall, charcoal densities are very low irrespective of the phase to which each sample belongs. A closer examination of the context details reveals that some of the highest-density values were obtained from assemblages likely to represent 'primary' deposition episodes (Fig. 10.16). These are (1291) (rake-out, B1.2), (1222) and (1223) (basal burnt fill layers, B1.3), (1349) (burnt fill, B1.3), (1391) (rake-out, B1.4) and (1386) (hearth, B1.4). High values have also been recorded for 'specialized' contexts such as (1390) (stakehole, B1.4) and (1332) and (1344) (bin F.215, B1.2), plus one external layer (1310) and an infill deposit (1283).

The distribution of Fr/Pr values appears to follow similar patterns (Fig. 10.16). Thus, comparatively low indices register the rake-out (1291), the bin F.215 deposit (1344), the burnt-fill layers ((1223) and (1349)); note the zero Fr/Pr value for (1318)) and the external deposits ((1351) & (1396)). By contrast floor surfaces ((1423), B1.2) gave, perhaps predictably, high Fr/Pr values. Some variation is also evident in that certain external areas (1315) and burnt fill layers ((1222) & (1319)) display higher values compared to their counterparts in the same areas. High proportions of indeterminate fragments were also recorded for the stakehole fill (1390).

The charcoal assemblages of Building 1 have given very low diversity values (all but nine contexts registered indices of less than 0.50; Fig. 10.16). The lowest are those of (1358) (floor, B1.4) and the burnt fills from the destruction level (B1.3). By contrast, rake-out (1437) and infill layer (1244) have given relatively high diversity values. The high taxonomic diversity observed for the stakehole assemblage (1390) might indicate its secondary origin (e.g. as re-deposited fill) given also its high proportion of indeterminate fragments.

Multivariate analysis (Figs. 10.17–18)

Figures 10.17–18 show the correspondence analysis scatterplots of all charcoal assemblages from Building 1. The first principal axis separates between samples displaying higher frequencies of oak (*Quercus*),

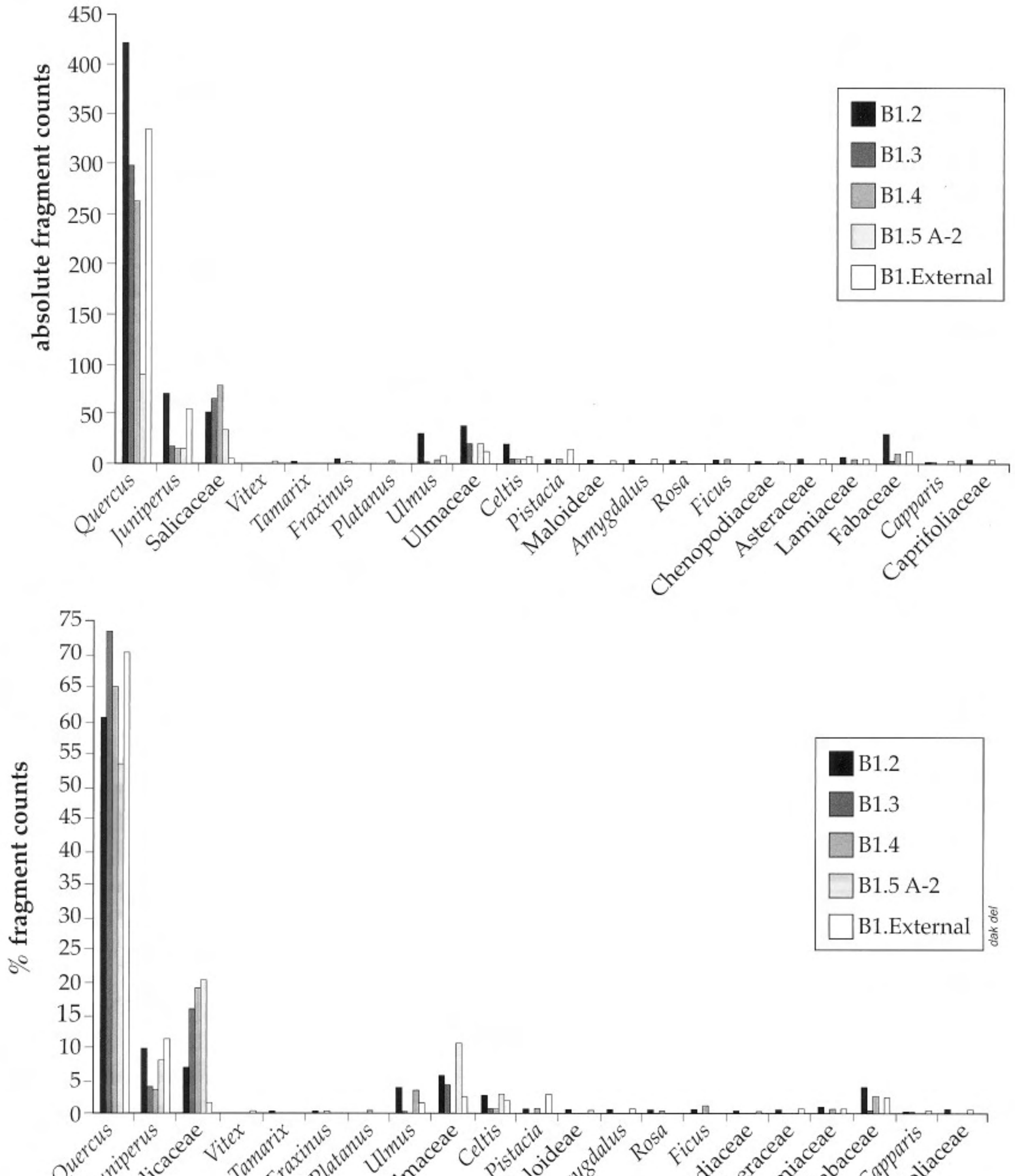

Figure 10.15. *Çatalhöyük-North Area: summary absolute and percentage fragment counts for all samples examined from Building 1 contexts (samples have been grouped by building phase).*

juniper (*Juniperus*), terebinth (*Pistacia*) and shrub taxa (Asteraceae, Lamiaceae, Fabaceae, *Rosa*) and those dominated by willow / poplar (Salicaceae). The second principal axis pinpoints the clear differentiation of bin F.215 ((1344), dominated by *Celtis*, *Ulmus*-Ulmaceae) from the rest of the charcoal assemblages.

What these scatterplots show is that there is a clear overlap in terms of sample composition between contexts belonging to the occupation phases (B1.2 & B1.4) and the external deposits (B1.E). All three phases hold for the most part quite diverse assemblages. The burnt-fill layers on the other hand are less diverse, being dominated by oak (*Quercus*)

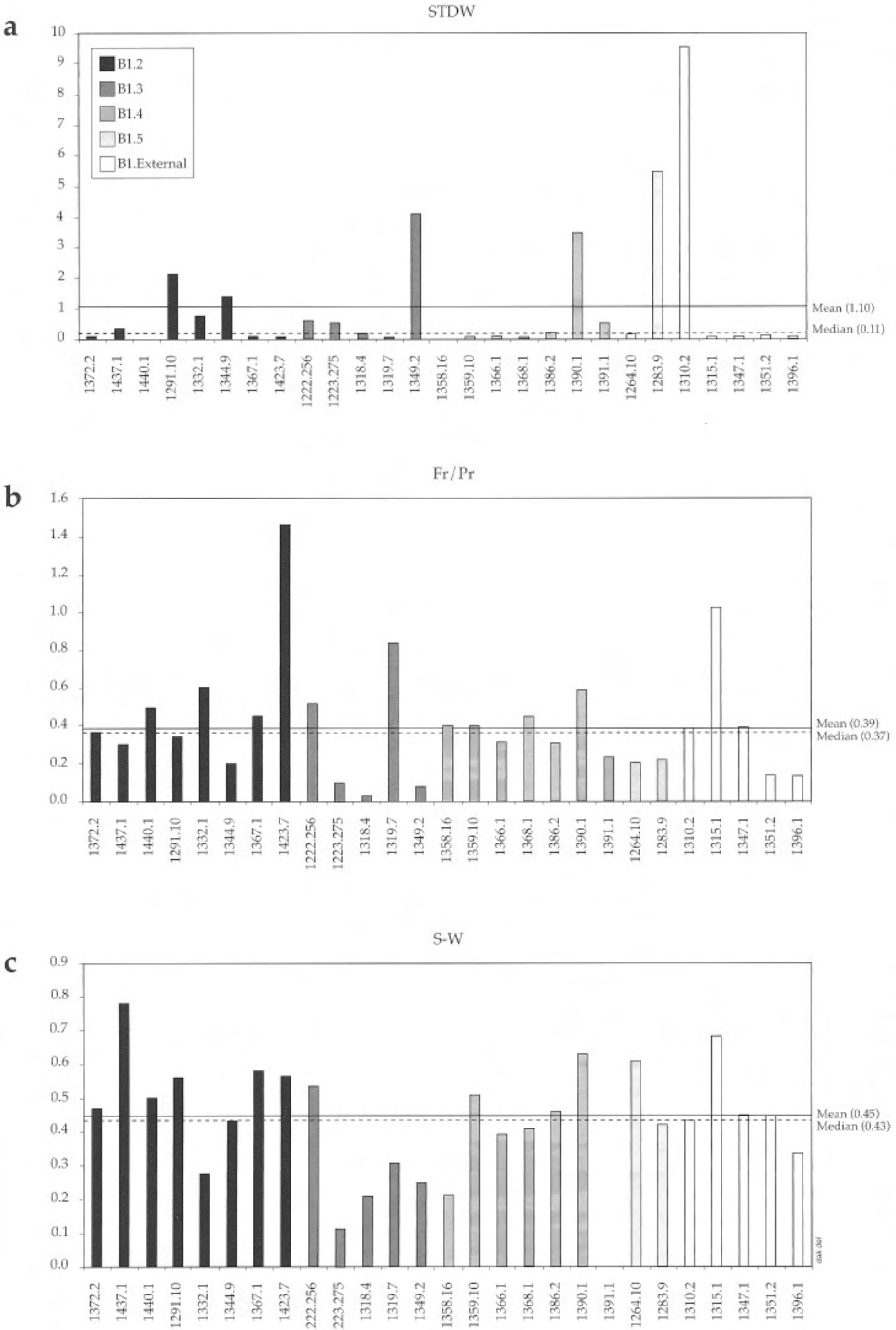

Figure 10.16. *Çatalhöyük-North Area: bar charts showing values of: a) density; b) Fr/Pr; and c) diversity measurements for all sampled contexts of Building 1 (column groups from left to right: phase B1.2; B1.3; B1.4; B1.5; B1.External).*

and Salicaceae. Somewhat exceptional in what concerns its sample composition appears to be (1344) (bin F.215, dominated by elm and hackberry).

Discussion

Overall, the few charcoal assemblages examined from Building 1 display very complex taphonomic histories. This may be a reflection, at least in part, of the small sample size. Variation is also evident in what concerns sample composition and, more distinctively perhaps, the disparate values of density and Fr/Pr for deposits belonging to the same context type (e.g. external layers, infills and burnt fills). The same appears to be true for the samples derived from the occupation phases, although much of the variation in this case could be explicable as the result of expected differences in preservation conditions between floor surfaces (kept overall very clean: Volume 3, Part 3) and rake-out layers.

In terms of sample composition, there seems to be a clear differentiation between assemblages deposited during the occupation phases and those belonging to the phase of controlled burning (B1.3). Apparently, the latter preserved in much higher proportions charcoal deriving from the burning of timber structures (e.g. oak). The high frequencies of oak in the external deposits may also indicate that these areas received at least some material from the burning episode.

The bin F.215 assemblages are more unusual, especially (1344). Although in terms of sample composition (1332) resembles the infill layers, the same cannot be said for (1344) that contains almost exclusively oak (*Quercus*), hackberry (*Celtis*) and elm (*Ulmus*). Besides charcoal, fill (1344) consisted of a thick deposit of charred lentils (reaching a depth of 2 cm) covered by a white/yellowish crust and patches of ash, all of which seem to suggest an *in-situ* burn-

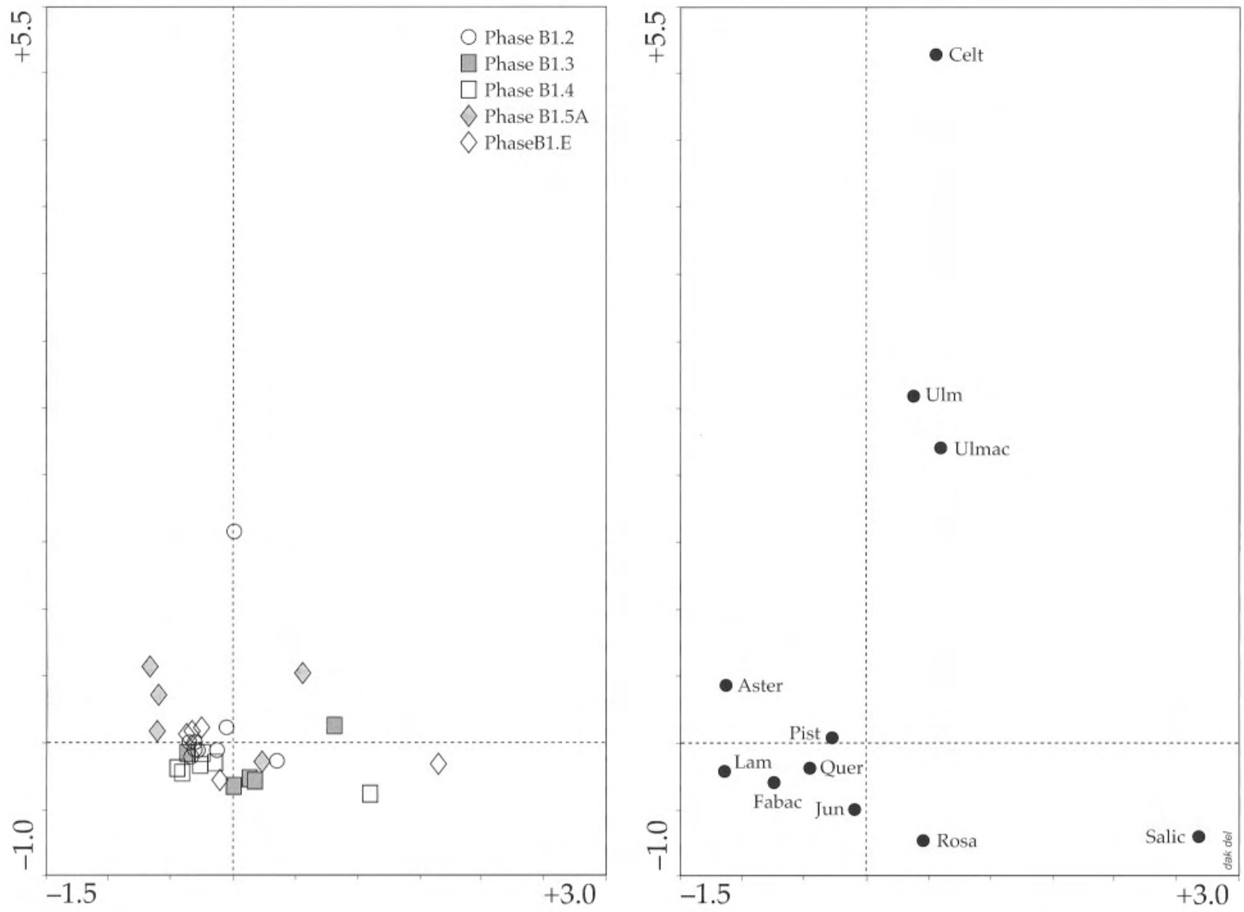

Figure 10.17. *Çatalhöyük-North Area: correspondence analysis scatterplots (left sample plot, right species plot) of all samples from Building 1.*

ing episode (for details see Volume 3, Part 3). The charcoal material of (1344) contained some very well preserved fragments of oak, elm and hackberry. Oak specimens in particular were very sizeable, in some cases retaining up to 24 annual rings, whereas elm and hackberry fragments comprised mainly small round wood (three to five annual rings, strongly curved; some larger fragments of elm were also found, a few of which preserved up to seven annual rings and appeared to have originated from timber-sized logs). Almost all pieces bore very clear signs of decay (mycelium and boreholes) thus indicating their burning as deadwood. The size and preservation status of the charcoal remains suggest an *in-situ* burning episode rather than the secondary deposition of debris inside bin F.215.

The overall characteristics of the charcoal assemblage paint a picture of a very controlled burning episode. It seems unlikely that the charcoal deposited inside bin F.215 represents the remains of structural timber collapsing from above during the general burning of Building 1 (Phase B1.3). The excavation records indicate that bin F.215 was burnt and infilled separately, prior to the general infilling of the southern half of Building 1 (Volume 3, Part 3). The fact that this burning event was contained inside bin F.215 certainly facilitated the preservation of sizeable fragments of charcoal, due to the protection afforded by the feature's plaster walls. A detailed discussion of the interpretation of this burning event goes beyond the scope of this report; however it would seem that the burning of bin F.215 formed part of a general sequence of controlled-burning episodes inside Building 1 (for further details and a full discussion of possible interpretations see Volume 3, Part 3).

Neolithic woodland catchments and woodland composition

Çatalhöyük is located on the Çarşamba alluvial fan formed by the homonymous river as it enters the Konya plain from its southern fringes (see also Fig.

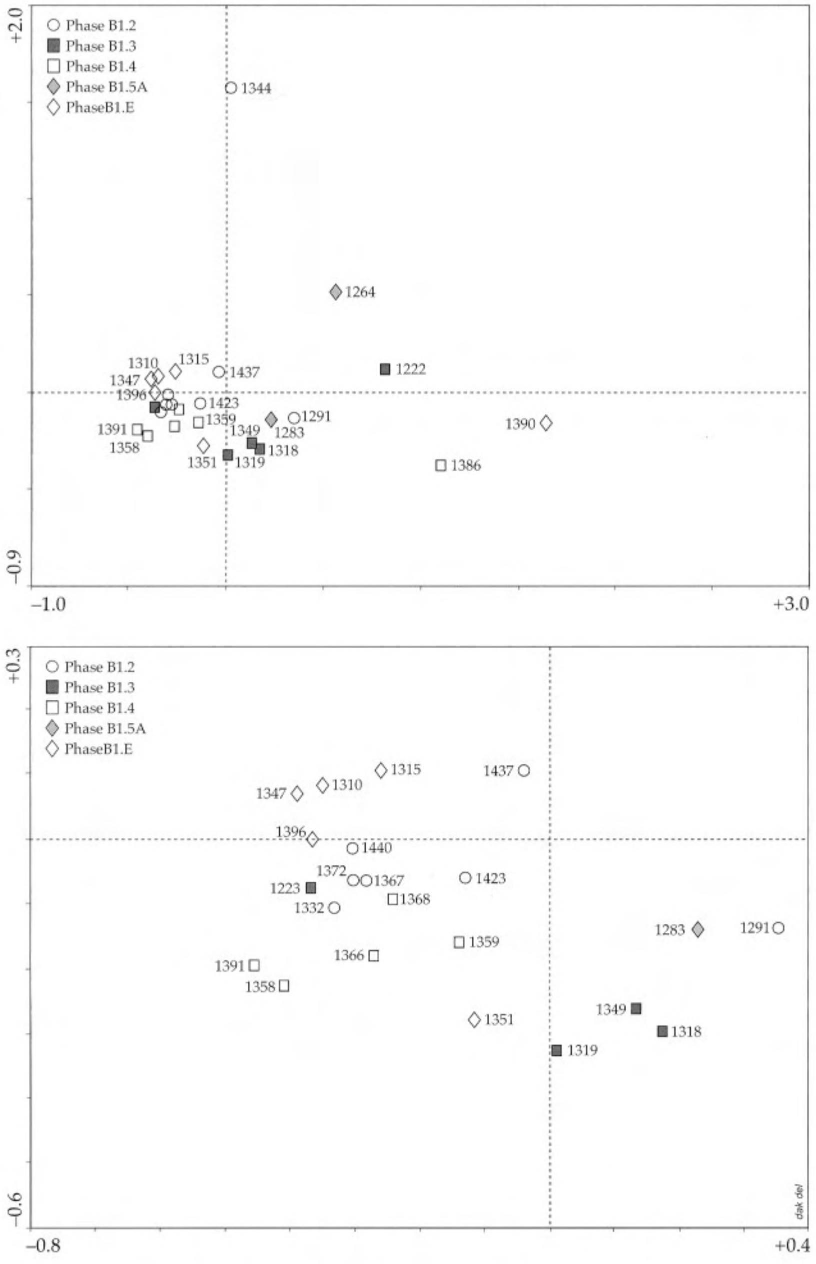

Figure 10.18. *Çatalhöyük-North Area: detail of correspondence analysis scatterplot for all samples of Building 1.*

10.19). Today, the area receives on average less than 300 mm of annual precipitation at the plain level, most of which occurs in winter and early spring. Evaporation is high (*c.* 6 mm/day) due to the low relative humidity and the steady northerly winds. The climate of the area is hence distinctly semi-arid with very dry/hot summers and cool winters (Driessen & de Meester 1969). The alluvial fan is presently under intensive cash crop cultivation (mostly wheat and various irrigated crops). To the north of the site, in the marl steppe of the Konya plain, overgrazed steppic vegetation prevails (dominated by low shrubs such as *Artemisia fragrans*, *Noaea mucronata*, *Alhagi camelorum* and *Peganum harmala*). Higher vegetation (apart from poplar plantations on the sides of irrigation canals) is restricted to the slopes of the volcanic massif of Karadağ and the hill zone (colluvial slopes, terraces and bajadas) on the southern borders of the Konya plain, composed mainly of open deciduous oak woodland.

An extensive program of geoarchaeological and palaeoecological research carried out at Çatalhöyük and the surrounding areas by the KOPAL team (Roberts *et al.* 1996; 1999; and see Volume 6, Chapters 5 & 6), coupled with the analysis of regional palaeoenvironmental sequences (Bottema & Woldring 1984; Eastwood *et al.* 1999; Fontugne *et al.* 1999; Reed *et al.* 1999; Roberts *et al.* 2001) have established the general pattern of climate, landform and vegetation configuration for central Anatolia and the Konya basin during the Neolithic (8500–6000 cal BC). These analyses of past vegetation and landforms have indicated that the modern landscape of the Konya plain bears little relation to the environmental conditions encountered by the Neolithic community of Çatalhöyük. A detailed palaeoecological interpretation of the charcoal record, focusing on the reconstruction of woodland composition, in particular the nature, spatial distribution and dynamics of woodland formations, has been presented elsewhere (Asouti & Hather 2001) drawing from the charcoal data, the off-site palaeoenvironmental evidence, the available modern ecological descriptions of tree vegetation from comparable regions in southwest Asia (Hillman 2000b; Kürschner 1986; Zohary 1973) and the contemporary distribution of soil and landscape units in the Konya plain (Driessen & de Meester 1969; de Meester 1971). Briefly, three main vegetation/landscape units have been defined (see also Table 10.7, Fig. 10.19):

I. Riparian and marsh vegetation

These vegetation types probably occupied an extensive area in the settlement environs, as can be surmised from the location of the tell on the alluvial floodplain formed by the Çarşamba river discharging into the Konya plain (cf. Roberts *et al.* 1996; 1999) (see Fig. 10.19). Their woodland component comprised the full array of wetland trees and shrubs encountered in the charcoal assemblages such as willow / poplar (Salicaceae), elm (*Ulmus*), ash (*Fraxinus*), tamarisk (*Tamarix*), plane (*Platanus*), alder (*Alnus*), chaste tree (*Vitex*) and clematis (*Clematis*).

Based on the current geomorphological reconstruction of the site's immediate environs, the suggestion has been put forward that the early spring floods of the Çarşamba river could have inundated (presumably on an annual basis) large parts of the alluvial plain, whilst backswamps and marshes occupied a substantial area in close proximity to the settlement (cf. Roberts *et al.* 1996; 1999). The location of Çatalhöyük at one of the lowest points of the floodplain and the fact that the Konya plain forms part of a closed hydrological system lacking natural outlets, further testify to the possibility that the alluvial floodplain was subject to substantial inundation. There is furthermore ample evidence indicating extensive marsh development prior to the drainage interventions of modern times (Driessen & de Meester 1969; de Meester 1970; 1971).

The continuous presence and relatively high frequencies of willow / poplar and elm throughout the sampled sequence at Çatalhöyük indicate that raised alluvial surfaces (e.g. hummocks) existed in close proximity to the site, which could have supported riparian vegetation. The charcoal data seem to suggest that such raised areas were probably under low clearance pressure for cultivation, since there is no evidence for the disappearance from the record of preferred wetland taxa (willow / poplar, elm) during the later phases of the settlement. Were such areas subject to intensive agricultural exploitation, the rapid impoverishment and fragmentation of wet woodland vegetation would have eventually led to the cessation of woodland regeneration and thus complete stand elimination, especially in the absence of drainage works for soil improvement that could have targeted the more frequently flooded and less forested areas (cf. Klimas 1988). The relative abundance of willow / poplar deadwood might also be considered as an indicator of a dense woodland canopy leading to the abscission of branches caused by light deficiencies and competition for growth (Millington & Chaney 1973). Alternatively, it could signify the occasional disturbance and death of individual plants by flooding episodes scouring parts of the riparian woodland and / or severe seasonal shortages in soil moisture (especially during the dry season: Asouti & Hather 2001).

More permanently-flooded areas and salt marshes could have supported stands of tamarisk-dominated woodland. Both tamarisks and alders can tolerate some degree of prolonged flooding. Tamarisks are furthermore well adapted to withstanding saline conditions and their occurrence indicates the presence of saline marshes and / or shallow pools nearby the site and possibly at the margins of the floodplain too as it prograded into the open, dry steppe (see Fig. 10.19). The charcoal record from the Neolithic site of Pınarbaşı, located some 15 km to the southeast of Çatalhöyük at the foothills of Karadağ, has indicated the predominance amongst wetland taxa of tamarisks, likely to have grown near or on seasonally-flooded shallow depressions in the plain, a setting which would have offered a suitable habitat for salt-tolerant tamarisk woodland (Asouti 2003).

II. Woodland steppe and treeless steppe

Towards the dry interiors of the plain, where mean annual rainfall rarely exceeds 300 mm and winter frosts are frequent, the dominant vegetation formations were probably more akin to dry steppe, with perennial shrubby chenopods (very abundant in saline dry depressions), wormwoods (Asteraceae) and various shrubs of the mint family (Lamiaceae) alternating with stretches of grassland (Zohary 1973). In places, as for example on limestone outcrops and chalky clays, nearby alluvial plains and at the foothills of colluvial slopes (away from the steppic marl soils that would have inhibited root penetration especially during the dry season) 'islands' of woodland steppe vegetation could have developed (Hillman 2000b; Table 10.7, Fig. 10.19).

In central Anatolia, such associations of widely spaced, drought-tolerant trees and shrubs (including the ubiquitous dryland hackberry-*Celtis tournefortii*) are encountered in Cappadocia almost exclusively on rocky outcrops (Woldring & Cappers 2001). The present author has also witnessed hackberry trees in settings typical of the 'wild orchards' of Anatolia (*sensu* Zohary 1973) in field and enclosed areas on the hillslopes surrounding the Konya plain (with an annual precipitation of 400–500 mm) and as sparse scatters on Karadağ (Asouti fieldnotes 1999 & 2001). Stretches of woodland steppe at the foothills of Karadağ have been described by Hillman (2000b), although it has not been possible to replicate these

Table 10.7. *Summary of landforms/habitats, vegetation catchments and reconstructed woodland composition in the Konya plain based on the charcoal evidence (available from this study and previous analyses at the campsites of Pınarbaşı: Asouti 2003), modern ecological analogues (see Zohary 1973; Kürschner 1986; Hillman 2000b; Woldring & Cappers 2001 and references therein) and recent vegetation prospections on Karadağ and the southern borders of the Konya plain (Asouti fieldnotes 1999 & 2001). Landform and rainfall data have been compiled from Driessen & de Meester 1969; de Meester 1971 (see also map with tentative reconstruction of the local distribution of vegetation catchments in Fig. 10.20).*

Water availability	**Landform type**	**Vegetation catchments**	**Reconstructed woodland composition**
seasonal inflows from upland runoff and meltwater	saline depressions / meadows, ephemeral streams	halophytic vegetation	chenopods (Chenopodiaceae), tamarisk (*Tamarix*)
permanent / seasonal water bodies	riverine pools, marshes, periodically-flooded alluvial floodplain	marsh vegetation, halophytes (shallow waters)	reed (*Phragmites*), tamarisk (*Tamarix*), alder (*Alnus*)
edges of rivers and springs	springs, riverbanks, raised alluvial surfaces	riparian vegetation	willow / poplar (Salicaceae), ash (*Fraxinus*), clematis (*Clematis*), elm (*Ulmus*), plane (*Platanus*), tamarisk (*Tamarix*), chaste tree (*Vitex*), fig (*Ficus*)
400–600 mm p.a.	well-drained foothill slopes, Neogene terraces, colluvial slopes, volcanic surfaces with good root penetration	oak-juniper park woodland	deciduous oak (*Quercus*), juniper (*Juniperus*), maple (*Acer*), legume shrubs (Fabaceae), wild plums (*Prunus*), rosebush (*Rosa*), buckthorn (*Rhamnus*), hackberry (*Celtis*), pears / hawthorns (Maloideae), honeysuckle family (Caprifoliaceae)
~300 mm p.a.	limestone / chalk and rocky outcrops, edges of foothill zone, moist steppic margins of alluvial plains	woodland steppe	almond (*Amygdalus*), terebinth (*Pistacia*), hackberry (*Celtis*), buckthorn (*Rhamnus*), wormwood (*Artemisia*, Asteraceae), caper (*Capparis*), mints (Lamiaceae)
<250 mm p.a.	arid plain interiors, marl steppe with poor root penetration	treeless steppe, low shrubs	wormwoods (Asteraceae, *Artemisia*), chenopods (Chenopodiaceae), mints (Lamiaceae)

observations during recent vegetation prospections (Asouti fieldnotes 1999). Outside Anatolia, the closest present-day ecological analogues are represented by woodland steppe in northeast Syria, in the areas of Jebel Abdul Aziz, Jebel Abu Rujmein and Jebel Bishri (Hillman 2000b), in southern Jordan (Kürschner 1986) and the Kurdo-Zagrosian forest steppe in Iran (Zohary 1973). Almonds (*Amygdalus orientalis*, *A. korschinskii*) and terebinths (*Pistacia atlantica*) are the dominant species, occasionally associated with hawthorns (*Crataegus aronia*) and shrubby buckthorns (*Rhamnus*). The shrub layer in these open woodlands may include wormwoods (*Artemisia herba-alba*), capers (*Capparis*), rosebushes (*Rosa*) and various xerophytic hemicryptophytes of the Lamiaceae family such as *Phlomis* spp. The Syrian case studies suggest that woodland-steppe communities can also thrive in habitats where soil moisture is enhanced through the presence of ephemeral watercourses (wadis), seasonal water bodies and landform features such as breaks in slope which improve soil drainage (Hillman 2000b).

In central Anatolia, the sole archaeological site that has produced evidence suggesting the presence of woodland steppe as a separate vegetation type during the Neolithic is Pınarbaşı (charcoal samples from all excavated areas were dominated by *Amygdalus*-almond and *Pistacia*-terebinth and also included most of the associated taxa mentioned above (Asouti 2003). The location of Pınarbaşı right on the foothills of Karadağ and its very close proximity to seasonally-flooded marshes would have offered a suitable setting for forest steppe vegetation. Until recently, charcoal evidence indicating similar vegetation types had been produced only for regions outside Anatolia such as northern Syria (Helmer *et al.* 1998; Roitel & Willcox 2000), Iraq (Watkins *et al.* 1991), the Zagros highlands (Willcox 1990; van Zeist *et al.* 1984) and Jordan (Willcox 1992a). The available terrestrial pollen records supplemented by deep-sea cores (Rossignol-Strick 1999) lend additional support to the Pınarbaşı charcoal record indicating the north-

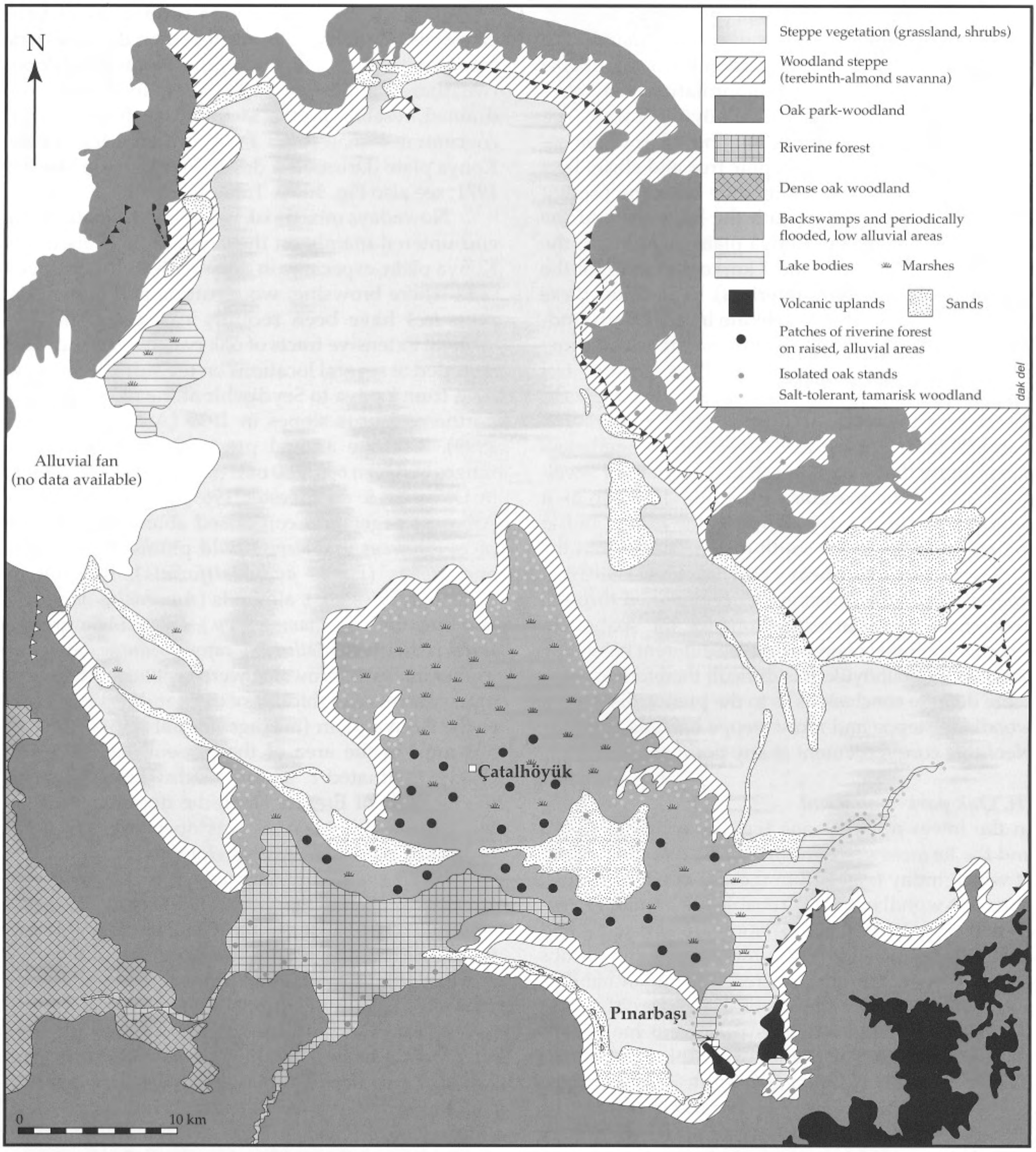

Figure 10.19. *Map of the Konya plain showing a tentative reconstruction of the different vegetation catchments based on the charcoal evidence from the archaeological sites shown on the map, the available palaeoecological and geomorphological analyses, the modern distribution of soil and landscape units, and vegetation descriptions from the same area and ecologically-comparable regions in southwest Asia (see text for full references). The definition of landscape units has been based on the soil maps published by de Meester 1971 and Driessen & de Meester 1969 (vegetation boundaries not to be scaled; the spatial extent of the floodplain follows its modern configuration).*

wards extension of woodland steppe during the early Holocene to encompass parts of central Anatolia.

Based on the Pınarbaşı evidence it is reasonable to infer that similar vegetation formations may have existed in the environs of Çatalhöyük as well. Yet, the regular presence in the Çatalhöyük midden sequence of charcoal from steppic tree and shrub taxa is more difficult to accommodate with the present distance of the tell from both the hill zone and the steppic interiors of the Konya plain (*c.* 12 km to the south for the hillslopes and 7 km to the north for the Konya plain dry steppic interiors). In addition, these species are not known to tolerate increased groundwater availability, backswamp habitats and fine-grained alluvial soils, and are furthermore not congruent with riparian woodland environments in this part of the world (Hillman 2000b; Woldring & Cappers 2001; Zohary 1973). It remains nonetheless a possibility that woodland steppe vegetation developed also at the margins of the alluvial plain as it prograded into the dry steppe to the north, and at higher locations to the south further away from the backswamps and the heavy alluvial clays. There is at present very little direct evidence obtained through geoarchaeological investigations for the spatial extent of the alluvial plain during the different habitation periods of Çatalhöyük. It is difficult therefore to reach some definite conclusions as to the precise distance of woodland steppe and moist steppe habitats from the Neolithic core settlement at any point of time.

III. Oak park-woodland

In the lower upland zone (i.e. the colluvial slopes and the terraces surrounding the Konya plain) most of which today falls within the 400–500 mm isohyet open oak woodland was probably the dominant vegetation type. With this formation are also identified a wide array of winter deciduous trees and shrubs which show a distinct preference for open habitats and exhibit some tolerance of dry and cold conditions. These include various pears and hawthorns (Maloideae-*Crataegus*, *Pyrus*), wild plums (*Prunus*) (Davis 1965, 23; Hillman 2000b), dryland hackberries (*Celtis*), almonds (*Amygdalus*), terebinths (*Pistacia*), junipers (*Juniperus*) (Davis 1965, 84; Zohary 1973, 349), maple (*Acer*, particularly the dryland maple-*Acer obtusifolium*) (Davis 1965, 23; Hillman 2000b) and fig (*Ficus*), the latter occurring on rocky outcrops and ravines near sources of fresh water (Hillman 2000b). Undershrubs may comprise various light-demanding taxa such as woody legumes (Fabaceae) and rosebushes (*Rosa*) thriving in natural openings and cleared spaces (Le Houérou 1985; Zohary 1973). Such vegetation formations of variable density might have developed on the limestone Neogene terraces and the reddish-brown hillslopes (weathered limestone, in places deep and well drained, resembling the Mediterranean terra rossa) concentrated mainly on the southern edges of the Konya plain (Driessen & de Meester 1969; de Meester 1971; see also Fig. 10.19, Table 10.7).

Nowadays mixed-oak woodland formations are encountered mainly on the southern borders of the Konya plain, especially in areas with well-developed soils where browsing, woodcutting and cultivation pressures have been recently eased and/or proscribed. Extensive tracts of oak park-woodland were recorded at several locations on the sides of the main road from Konya to Seydişehir at the foothills of the northern Taurus slopes in 1999 (Asouti fieldnotes 1999). Average annual precipitation in this area ranges between 600–700 mm (rainfall curves mapped in Driessen & de Meester 1969; de Meester 1971). Arboreal vegetation comprised abundant oak coppices (*Quercus macrolepis*), wild plums (*Prunus spp.*) and pears (*Pyrus amygdaliformis*), hawthorns (*Crataegus orientalis*), almonds (*Amygdalus orientalis*) and buckthorns (*Rhamnus spp.*), alongside a ground flora rich in *Tainiatherum caput-medusae*. Signs of former intensive browsing were visible in the stunted topiary forms and thickets of trees and shrubs. Closer to the Konya plain (average annual rainfall of 400–500 mm) in the area of the present-day village of Gökyurt, situated *c.* 35 km southwest of Konya at the foothills of Erenler Dağı, the dominant vegetation on the valley slopes was open oak woodland including wild pear (*Pyrus eleagrifolia*), wild plum (*Prunus* sp.), almond (*Amygdalus orientalis*), dryland hackberry (*Celtis tournefortii*), oleaster (*Eleagnus angustifolia*) and rose (*Rosa canina*). Stands of willow (*Salix* sp.) mixed with ash (*Fraxinus* sp.) punctuated the banks of the seasonal watercourses dissecting the valley (Asouti fieldnotes 2001).

More varied forms of park-woodland were encountered during vegetation prospections in eastern Karadağ (Asouti fieldnotes 1999). On the north-facing exposures of colluvial slopes and ravines, deciduous oaks (*Quercus trojana*, *Q. macrolepis*) were dominant, together with spiny almonds (*Amygdalus orientalis*). On southern slopes, light-demanding low terebinth shrubs (*Pistacia atlantica*) abounded alongside almonds and hawthorns (*Crataegus orientalis*) and buckthorns (*Rhamnus* spp.) Cultivated varieties of species otherwise not encountered in the area (e.g. apple trees-*Malus* sp.) were also spotted in garden fields and enclosed areas. Although there was some evidence for the use of ligneous plants as building and fencing material, the surrounding slopes were nonetheless well wooded, despite the fact that the most commonly-used fuels in this area today are oak, juniper and hackberry branches, occasionally supplemented by dry stalks of cultivated sunflowers (Aylan Erkal pers. comm.). This was probably due to the preference of the local villagers to use planted poplars instead of the forest timber as the principal raw material for roof construction, and the evidence for the intensive management of woodland trees (particularly oaks) through coppicing and pollarding. The few forest reserve areas existing in Karadağ preserved some of the best examples of oak park-woodland. Vegetation in these areas was much denser and diverse, with trees often reaching a height of 6–7 m. Arboreal vegetation comprised oaks, wild plums, pears, hackberries and rosebushes, accompanied by a ground flora rich in annuals (as opposed to grazed areas where *Astragalus* and *Tainiatherum* were dominant).

Concerning the possibility that tree taxa such as deciduous oak, juniper, almond, hackberry, wild plum and terebinth (widely regarded as typical of woodland steppe and park woodland in the central Anatolian region) might also have occurred in the alluvial setting of the Çarşamba floodplain, alternative interpretations depend to some degree on the proposed reconstruction of the prevailing landform and soil types around Çatalhöyük during the Neolithic. Modern ecological analogues available from this region and similar environments elsewhere in southwest Asia (Hillman 2000b; Zohary 1973) would suggest that a combination of well-drained soils (colluvial, terra rossa, limestone terraces, volcanic slopes) and rainfall in the range of 300 to 400–500 mm per year constitute a suitable environment for the development of woodland steppe and oak park-woodland respectively (see also Table 10.7).

The botanical record considered in the light of modern vegetation distribution and the habitat preferences of the taxa in question would suggest that oak park-woodland and denser 'forest' vegetation could have been available at a distance of >10 km to the south of the Neolithic settlement. The limiting factor would have been not so much precipitation (allowing also for the higher rainfall values modelled for the first half of the Holocene in the region; see next section) but, more decisively, soil distribution. Leaving aside lacustrine plain soils (in their majority consisting of marl steppe extending over the greater part of the Konya plain) that are not conducive to tree growth due to very poor root penetration, the immediate environs of the tell seem to have consisted mainly of fine-grained alluvium with a high clay content also comprising extensive backswamps (Driessen & de Meester 1969, 35; Roberts *et al.* 1996). A major limitation for the growth of park-woodland species, particularly oak, on deep fine-grained alluvia is their reduced water availability, ultimately resulting in intensive competition with annuals for ground moisture. As Hillman notes, the absence of trees from alluvium as opposed to better-drained soils 'apparently reflects the greater availability of moisture in coarse-textured soils and around rocks and the failure of rainwater to penetrate fine-grained soils beyond the upper levels exploited by herbs' (Hillman 2000b, 54). Grasses are thus represented much better than ligneous species on such soils, especially annuals that are well adapted in taking advantage of seasonal variations in the availability of surface ground moisture (Blumler 1993; Byrne 1987; Hillman 2000b).

Zohary (1973) has further stressed that hydromorphic alluvial soils (e.g. heavy backswamp clays and very fine floodplain soils) are generally characterized by high water-table levels, which tend to inhibit root penetration and soil aeration. There are naturally many other ecological factors besides soil aeration that could have affected tree growth such as soil structure and temperature, seasonality of flooding, organic matter content and water-table movements, all of which are in the case of Çatalhöyük only partially understood based on the amount of geoarchaeological information currently available. If however one accepts that alluvial hydromorphic soils were the dominant soil type in a radius of ~10 km around Çatalhöyük (as implied by the current geomorphological reconstruction), then one also has to accept that oaks and the associated park-woodland species were procured from the same minimum distance (that is the colluvial hillslopes and the Neogene terraces to the south of the settlement: see Fig. 10.19).

In relation to the ecological preferences and tolerances of oak trees in particular, another possible growing location could represent the sand ridges situated halfway to the hillslope zone (*c.* 7.5 km to the south of the settlement) (see Fig. 10.19). It has to be stressed, however, that there is no historical record of oaks growing in the sand ridges, the main reason being that these have been some of the oldest dry-farmed soils in the area (Driessen & de Meester 1969). Both species of oak for which such information is available (*Quercus robur* and *Q. cerris*) can grow successfully on sandy (and clayey) soils on condition that they comprise well-drained, raised surfaces with a comparatively low water table and low evaporation rates (Gordon Hillman pers. comm.). Yet, the possibility must also be considered that, even if oak stands did grow there, the sand ridges are very likely to have been cleared for agriculture at a very early stage of habitation. It is thus difficult to argue that they could have represented a viable timber and firewood supply throughout the one thousand years or so of the occupation of Çatalhöyük. The existence of levées (yet to be ascertained through geoarchaeological coring) might alter in part this interpretation, suggesting that a sustainable oak supply could have been available at a relatively short distance from the settlement (with the same cautionary note concerning clearance for cultivation). However, the geoarchaeological evidence as it stands at present does not support such an alternative (Roberts *et al.* 1996; 1999).

Vegetation and climate change

For the time period corresponding to the early Holocene (~8500–7000 cal. BC) the palaeoecological evidence currently available has indicated that climate conditions favourable to woodland expansion prevailed in central Anatolia (Roberts *et al.* 2001). The palaeoenvironmental sequences available from several locations in the Konya basin (Fontugne *et al.* 1999; Roberts *et al.* 1999) supplemented by high-resolution pollen, diatom and ostracod data from the crater-lake of Eski Acıgöl in Cappadocia have also indicated that climate conditions were moister at the time of the founding of Çatalhöyük (~7400 cal BC) allowing for woodland expansion and the proliferation of mesic taxa (e.g. elm, hazel) that lasted until ~7000 cal BC (Roberts *et al.* 2001).

The evidence for long-term vegetation transformations and their relation to climate change in the Konya plain is however somewhat more difficult to evaluate. The available pollen data from the Konya basin are restricted to a single published pollen diagram from Akgöl Adabağ (Bottema & Woldring 1984). This pollen sequence has been interpreted as indicating an increase in deciduous oak and possibly juniper (dated by interpolation at ~8000 cal BC), with other deciduous elements also appearing for the first time such as hornbeams (*Carpinus / Ostrya*) and hazel (*Corylus*) (Bottema & Woldring 1984). There were no pollen spectra preserved corresponding to the earliest excavated habitation phases at Çatalhöyük. Shortly after 7000 cal BC coniferous forest started to expand, with the synchronous retreat of oak woodland. Recent palynological investigations in the same area broadly confirm the general pattern of vegetation evolution summarized above (Neil Roberts pers. comm.). These trends overall seem to concur with the general pattern of climate change inferred from other palaeoecological investigations in the Konya plain and the multi-proxy records available from Cappadocia.

However, the coarse chronological resolution of the Akgöl sequence and the distance of the site from both the major Neolithic settlements of the area (*c.* 100 km from Çatalhöyük and 50 km from Canhasan III) have compromised the usefulness of the pollen data for tracing with the detail necessary for this purpose climatically-induced changes in woodland composition and the impact of human activities on the prehistoric vegetation. In addition, most of the arboreal taxa that (human impact notwithstanding) normally abound in similar ecological settings are either insect-pollinated (*Prunus*, *Amygdalus*, Maloideae, *Celtis*, *Acer*) or have poor pollen dispersal (*Pistacia*) and are thus unlikely to be adequately represented in pollen diagrams (Hillman 1996, 183; Woldring & Cappers 2001).

Although further analytical work is necessary, spanning a wider array of habitation sites from different time periods, the present study and previous analyses from Pınarbaşı (Asouti 2003) and Canhasan III (Willcox 1977; 1978; 1991) have enabled tracing some general patterns in vegetation change though time, which broadly agree with the data made available through recent palaeoecological investigations (Eastwood *et al.* 1999; Fontugne *et al.* 1999; Reed *et al.* 1999; Roberts *et al.* 1999; 2001). Although the early midden samples from Çatalhöyük suggest the concentration of firewood-collection activities on the wetland zone, this does not necessarily imply the absence of oak from drier localities further upstream. Oak, despite its extremely low frequencies, is still present in the charcoal samples alongside most of the associated park woodland and woodland steppe taxa (i.e. hackberry, almond, terebinth, wild plum, hawthorn / pear).

Furthermore, the gradual rise in the presence and abundance values of juniper in the charcoal samples from Levels VII–IX could be considered as an indication for the gradual development of drier conditions that favoured the expansion of juniper stands from ~7000 cal BC onwards. However, it could equally signify the invasion of oak park-woodland by junipers due to the selective logging of oak stands for timber and firewood (see also next section); junipers are generally considered as aggressive colonizers of deciduous woodlands thinned for timber and / or firewood, and compete successfully with oaks (Zohary

1973, 246). The synchronous rise in the presence and frequencies of shrubs (legumes, wormwoods and mints) might also indicate increasing logging and grazing pressures on oak park-woodland and steppic vegetation (Asouti & Hather 2001).

The charcoal sequence from Pınarbaşı has also provided some indications for an overall reduction in the presence and frequencies of wetland taxa towards the late Neolithic/Chalcolithic phases of the site (Asouti 2003). Preliminary observations on some of the Chalcolithic charcoal material retrieved from the recent excavations in Çatalhöyük West (Chalcolithic) have further indicated the nearly complete substitution of oak by juniper as the dominant taxon, coupled with a substantial rise in the frequency of terebinth (*Pistacia*) charcoal (Asouti unpublished material). Although work on the Chalcolithic assemblages is still at a very preliminary stage, it would seem very likely that such changes reflect a major shift in species availability caused by climatic factors and the transformation of the hydrological regimes of the Çarşamba river, rather than a culturally-derived re-orientation of wood-gathering activities.

Hence it is plausible to argue that the charcoal data offer at least some evidence in support of a pattern of environmental change characterized by a general decline in total precipitation after ~7000 cal. BC, although distinguishing between the possible effects of climate fluctuations and human induced changes in woodland composition remains highly ambiguous. Furthermore, the regular presence in the sampled midden sequence of moist steppe and oak park-woodland taxa indicates that average precipitation in the environs of the Çarşamba fan (today receiving ~300 mm of annual rainfall) must have been higher during the Neolithic, thus favouring the establishment of park-woodland vegetation on the lower hillslope zone. The charcoal data thus suggest that pollen-based arguments for the slow re-expansion of arboreal vegetation in central Anatolia during the early Holocene (Kuzucuoğlu 2002) most likely present an overly-conservative reconstruction of the Neolithic vegetation, biased as they are by the invisibility of several native steppic tree taxa (e.g. of poor pollen dispersers such as Rosaceae, Maloideae and *Pistacia*) in the regional pollen record.

The steep increase observed in the frequencies of oak charcoal from ~7000 cal BC would appear to be at odds with a palaeoclimatic model suggesting the onset of a gradual decline in total precipitation from approximately the same time period. A more convincing interpretation would be that it represents a culturally-derived shift in wood-procurement strategies, largely unrelated to climatic influences and changes in the net availability of woodland resources that were probably too gradual to exert a visible effect on firewood and timber provisioning. As mentioned before, one could not argue for the complete absence of oak from the area during the early stages of habitation in Çatalhöyük, since oak fragments are present sporadically in the earliest excavated charcoal assemblages and the regional pollen data from Cappadocia have suggested at least some presence of park woodland vegetation during this period (~7400 cal BC) in the upland zone (Roberts *et al.* 2001). On the basis of the presently-available evidence, it seems more likely that this major temporal change in sample composition marks the expansion (in the spatial sense) of the firewood- and timber-procurement activities during the later phases of the site further away from the settlement and its immediate wetland environs. That this might be the case can be further inferred by the very low frequencies of oak charcoal in the early deposits (indicating their derivation from small isolated scatters of oak trees rather than well-developed oak woodland growing in close proximity to the site) and the rather abrupt increase in oak frequencies within the Level VII-Pre-XII.A middens. Such a shift might have been also instigated, at least in part, by the gradual degradation of wetland vegetation due to (variable) clearance pressures.

Fuel and timber exploitation

Selection of domestic and 'industrial' fuels

The charcoal evidence has indicated that during the earliest-known phases of the settlement firewood collection concentrated in those woodland catchments that were closest to the main settlement, such as the alluvial riparian woodlands. An important exception appears to constitute hackberry (*Celtis*), which could have been procured from woodland steppe vegetation (note however the limitations of the available geoarchaeological evidence already mentioned above in defining the spatial extent of the alluvial floodplain and hence the approximate distance of Çatalhöyük from moist steppe habitats). The importance of hackberry fruits as a collected fruit crop (see Chapter 8) could be an indication that much of the hackberry wood reached the settlement alongside the tree's fruit produce, a strategy that would have presented obvious benefits in terms of activity scheduling and labour investment in foraging and firewood collection. Otherwise, oak and the majority of the remaining fruit and shrub taxa appear with very low frequencies in the early charcoal samples. The apparent abundance of deadwood among specimens identified as willow/poplar (Salicaceae) suggests the recurrent collection of deadwood (dead branches and stems) accumulated as a result of either dense woodland growth or again of recurrent flooding episodes that scoured parts of the riparian woodland killing off individual plants and/or entire stands.

The evidence of charcoal densities from the earliest excavated layers suggests that substantially less firewood was consumed during these early habitation phases (Pre-XII) of the settlement compared to later phases (Levels VII–IX). The analysis of the taphonomic characteristics of these midden samples indicated that the cause of their low charcoal densities could be attributed to the overall low intensity of firewood consumption rather than the effects of post-depositional charcoal deterioration. One possible interpretation for the low levels of wood collection may be that flooding episodes were more frequent during these early stages of habitation and hence unrestricted access to dry patches of woodland was more difficult to achieve. Such an explanation would accommodate the charcoal evidence with the results of the off-site excavations (KOPAL Area) and the geoarchaeological investigations (Volume 3, Part 4).

In addition, a distinct set of charcoal assemblages has been identified among the midden deposits of the early strata. The detailed analysis of their taphonomic characteristics has indicated that these deposits are very likely to represent non-domestic fuel refuse originating in external open fires maintained for the production of lime plaster (Volume 3, Part 2). A series of samples examined from stratigraphically-associated layers of burnt deposits have also given low densities of charcoal material which are comparable to those of the midden samples examined from the same levels. Although there is evidence that dung fuel had been used extensively in these firing episodes (fragments of burnt dung, mineralized dung pellets, etc.) the importance of dung fuel for lime burning cannot be overstated. The presence of melted silica in micromorphological thin sections from these layers has suggested fire temperatures >650°C (Chapter 19). It is extremely unlikely that charred wood particles could have withstood such burning environments without suffering substantial thermal degradation and breakage, even more so if residual charcoal layers had been subject to reheating through repeated burning episodes on the same locations. Another factor affecting charcoal preservation probably related to the structure of these open fires, set inside shallow pits and/or scoops without any surviving evidence for the existence of some kind of superstructure (e.g. earthen cover: Volume 3, Part 2). Furthermore, the analysis of animal bone and botanical macro-remains coupled with micromorphological thin sections have indicated that a wide assortment of materials were used to fuel these fires including bone, shell and animal dung (Chapters 8 & 19). This picture is mirrored in the charcoal data set; despite the adverse taphonomic conditions described above, the systematic subsampling of the open fires and the associated midden assemblages has made possible the retrieval of a broad range of taxa, including almost all the riverine, shrub and fruit taxa recovered in Çatalhöyük. It seems therefore very likely that the main consideration dictating the selection of fuel materials (including firewood) for lime burning was not their individual burning properties but instead bulk fuel availability.

The post-7000 cal BC midden samples (Levels VII–IX) are characterized by the predominance of oak, the relatively greater diversity of riverine taxa, and the higher frequency of juniper, wild plum, wormwoods, legumes and shrubby chenopods. Furthermore, the samples derived from the late middens have higher densities of wood charcoal compared to the early deposits. A relatively large proportion of the microscopically examined oak and willow/poplar charcoal bore signs of fungal decay. Possible interpretations for the recurrent presence of oak deadwood include its abundance in the natural vegetation (e.g. fallen branches on the woodland floor or collected from standing over-mature trees) and/or the regular use of defunct structural timber as fuel (for a comment on the occurrence of Salicaceae deadwood see above). Although there are no data available on the deadwood productivity of oak species in this region, Anatolian oaks are reportedly prone to attacks by heart rot (Chapman 1948). There is also sufficient archaeological evidence to demonstrate that buildings in Çatalhöyük underwent several phases of remodelling whilst an essential part of the demolition process was the removal prior to levelling of the wooden posts supporting the roof.

A series of possible interpretations for the differences observed in sample composition and charcoal densities between the early and later phases have been considered so far. Can they be explained as a result of differences in the availability of woodland resources? The palaeoecological evidence presented in the previous section would suggest that this is rather unlikely given that during the period corresponding to the earliest habitation of Çatalhöyük the prevailing climate conditions generally favoured woodland expansion. An alternative interpretation could be that these patterns have been introduced by context-related variation and thus do not represent 'real' differences in woodland exploitation between the early and the late phases of the settlement. Yet, this is also unlikely given that these differences were established through observations performed on external refuse deposits holding the accumulated debris of discarded fuel refuse and thus representing long-term patterns of fuel exploitation. Furthermore, through the detailed taphonomic analysis of the charcoal assemblages, it has also been possible to discount the influence of preservation conditions as the main causal factor. Indeed, the results of the taphonomic analysis appear to agree with the stratigraphic evidence indicating no major changes and/or breaks in the mode of midden deposition between the earliest strata and the greater part of the post-7000 cal BC phases.

Another alternative which merits consideration and seems best supported by the available evidence is that these differences in sample composition between the early and later phases reflect a major temporal shift in the range of woodland habitats exploited for firewood and timber procurement, possibly instigated by the potential consequences of increasing pressures on wet woodland catchments in the vicinity of the site. Although wetland taxa never really disappear from the record, their substitution as the dominant component in the charcoal samples by oak may reflect the progressive fragmentation of local riparian woodlands (growing on unstable raised alluvial areas likely to have been periodically scoured by river floods) that were regularly exploited for firewood and had been subject to at least some clearance for cultivation. In this sense it may be possible to argue for the gradual transformation of the alluvial floodplain from a 'natural' habitat into an anthropogenic/cultural landscape bearing the unmistakable signs of multiple human interventions adversely affecting riparian vegetation.

Currently established theories on the factors conditioning the consumption of firewood and dung fuel in prehistoric societies maintain that patterns of fuel use are largely determined by the availability of wood-fuel resources, with shifts to dung fuel being explained primarily as the result of lacking woodland resources or forest over-exploitation (Miller 1985; 1996). The evidence obtained from Çatalhöyük would suggest, however, that more complex processes may be at play at the settlement level; although firewood exploitation seems to increase through time, dung fuel continues to be used presumably on a regular basis (Chapter 8) whilst no obvious changes in the net availability of woodland resources can be argued for on the basis of both the charcoal data and the off-site palaeoecological record. By contrast, even allowing for the gradual impoverishment of the riverine vegetation, riparian trees and shrubs are not substituted by dung (the intensity of dung fuel use actually appears to have remained constant throughout the sampled sequence: see Chapter 10). Instead, oak becomes the dominant firewood species.

These patterns may imply that wood and dung fuel were used in complementary ways that could have been determined by seasonal differences in the availability of fuel resources (e.g. through the penning of animals close or inside the settlement at different times of the year: see Chapter 2) and the scheduling of activities likely to have been related to firewood procurement (e.g. clearance for cultivation, timber and foraging trips). Functional variations in the use of hearths and 'ovens' form another potential explanatory factor; it is possible that different types of fuel were valued for different purposes (e.g. the slow burning and long-lasting dung fuel for cooking, and firewood for heating, smoking and/or lighting). These patterns, manifested in the archaeological and the archaeobotanical record, are the object of ongoing research. Further possible explanations might include the consideration of cultural 'traditions' and inherited patterns of resource use, for which arguments drawing from the archaeological and subsistence record of the region have been developed elsewhere (Asouti & Fairbairn 2002).

Selection of timber species: the archaeobotanical and archaeological evidence versus the ethnographic record

Oak and juniper were the principal construction timbers in use at Çatalhöyük, as evidenced from the excavations conducted by James Mellaart and recent dendrochronological research undertaken at the site (Mellaart 1967; Newton 1996). As these studies have demonstrated, oak and juniper upright posts were used for the structural support of the heavy flat roofs consisting of layers of mud set on top of reed bundles and/or wooden poles. According to James Mellaart, the use of vertical posts (mostly unworked apart from the stripping of their bark) was widespread in structures of Levels XII–XI (Mellaart 1966) although no walls had been preserved to a sufficient height to indicate whether some kind of 'framing' was used for their internal support. By contrast, the fire-destroyed buildings of Level VI reportedly provided ample evidence for the existence of wooden frames, composed of vertical and horizontal squared timbers (mostly oak and juniper, with elm occasionally used for the vertical engaged posts) (Mellaart 1967). The engaged posts (either half-timbers or planks) divided the walls into several distinct units, which were further subdivided into horizontal panels. Towards the latest phases of the settlement (not dealt with in the recent excavations) the evidence for structural timber gradually declined, with very little evidence for its use in Level II buildings (Mellaart 1967).

Recent research has further elaborated on these findings, particularly concerning the individual life histories of built spaces and the treatment of timber elements. The complex sequence of building abandonment and re-use, either for raising new structures on the old layout or as open areas receiving domestic refuse, has been documented in detail (Volume 3, Part 2). Direct evidence for the retrieval of vertical posts and their re-use in other construction works, has also been obtained by dendrochronological studies. The sampling in 1995 of charred timber fragments from the cleaning of sections in the old Mellaart trenches and their subsequent analysis together with material from the old excavations suggested many cases of timber re-use, indicated by the occurrence of timbers with cutting dates earlier than the rest of the posts recovered from the same structure (Newton 1996, 52–7).

These data seem to accord with indirect evidence provided by the quantitative analysis of non-midden charcoal assemblages from the South Area. In them, it was observed that the deposits holding the highest concentrations of oak-wood charcoal were those associated with roofed structures, such as the general infill layers accumulated inside Buildings 17, 18 and the penning areas (Spaces 198 & 199). Although little archaeological evidence is available *per se* on the details of roof construction, it is likely that much of the oak charcoal in these samples actually derives from roof beams and/or thatching material. One possible cause may have been fire-related accidents (e.g. matting and/or exposed beams catching fire from sparks generated in hearths and 'ovens'). The dismantling and collapse of roofs during the demolition of disused buildings could have also contributed to the accumulation of charcoal debris (due to the breaking up of blackened and partially-charred roof elements), which was subsequently incorporated in the infill matrix. The presumably lighter structures covering the barn enclosures (Volume 3, Part 2) could have witnessed similar processes. It is possible that rotting-away wooden elements were periodically burnt as part of general cleaning and/or repair routines. The seed assemblages recovered from the penning areas have indicated the *in-situ* burning of dung (large concentrations of chaff, small-seeded legumes and grasses: Chapter 8), which might also reflect cleaning activities.

The evidence from the charcoal samples derived from a series of open-fire layers within Space 115 would appear to corroborate such a hypothesis. The charcoal assemblages comprised almost exclusively heavily-degraded (fungal decay) fragments of oak. Such large concentrations of oak deadwood have been retrieved elsewhere only amongst the burnt horizons of Building 1 (North Area). It might thus be the case that these open fires represent the burning of defunct structural timber. The fact that it was burnt outdoors instead of being recycled in domestic fire installations may indicate an accidental event involving internal wooden elements scorched by fire to the extent that they were unusable any longer as either structural timber or firewood suitable for domestic consumption. However, there is also the possibility that the charcoal scatters retrieved from both the infill layers and the penning deposits represent residual material unrelated to or mixed with parts of roof debris (in view also of the very low charcoal densities recorded for these context types). In this case, the general predominance of oak charcoal in these samples would simply mirror its status as one of the preferred fuel materials (as is indicated by the predominance of oak charcoal in the post-Level XII midden samples). Based on the available evidence it is not possible to exclude either alternative.

The task of procuring large quantities of timber could have been a communally-organized activity, involving several households and a serious investment in effort and time from the part of the local community. The proposed reconstruction of woodland catchments suggests that timber had to be transported to the settlement from some distance upstream. Given the lack of pack animals during this period, it is possible that most of the oak and juniper timber was floated down the Çarşamba river to the outskirts of Çatalhöyük. This might have been the object of special woodcutting trips arranged to take place roughly at the beginning of spring, when river discharge would be particularly strong and construction/repair activities could be scheduled to take place during the oncoming dry season. Direct evidence obtained from the dendrochronological examination of wooden posts from buildings of Level VI suggests that this is a plausible scenario given the clustering of felling dates observed amongst the surviving timbers of certain buildings (Newton 1996, 53).

That wood probably had to be brought in from some distance instead of resorting to the locally-available willows/poplars and elms, may reflect the recognition by the Neolithic inhabitants of Çatalhöyük of the superior qualities of oak and juniper as timbers. Both produce very sizeable and tough poles, suitable for withstanding mechanical pressures in the long term, and are much more resistant to fungal attacks (especially juniper) than the majority of riverine species. Furthermore, the removal of bark and the trimming of oak and juniper posts could have generated some quantities of surplus firewood, especially during intensive building periods. Vestiges of defunct timber unsuitable for further use could also have entered the domestic fireplace as fuel. The persistent occurrence and the high frequencies of oak and (less so) juniper across samples belonging to the late midden and non-midden contexts, indicate that these taxa were regularly used not only as timber but as firewood too (through direct procurement and/or the consumption of timber preparation by-products and defunct structural material).

Such a pattern of timber-related activities accords with the available ethnographic evidence suggesting the regular recycling of timber as firewood in traditional peasant societies. For example, in rural Colombia old and/or abandoned houses are regarded as communal property and their timber can be used as fuel by all members of the community (Devres Inc. 1980, 28). Amongst the Kurdish villages of northern Iraq, where deciduous oak trunks are commonly used as pillars and/or rafters in houses, the tendency of over-mature oaks to be readily attacked by heart rot meant that much of their timber would eventually find its way into the fireplace, when it had exhausted its structural lifetime (Chapman 1948). Ethnoarchaeological research in northeastern Anatolia has also indicated that timber elements retrieved from roofs, doors, lintels and windows are always removed upon the abandonment of buildings in order to be re-used either immediately or at some later date (Hopkins 1999).

More region-specific studies of traditional architecture in central Anatolia have indicated the very complex nature of roof building, and the range of practical considerations that need to be accommodated, especially in areas where construction timber has to be fetched from a distance (Kafesçioğlu 1949, 44–55). Amongst the villages of the Ankara district, locally-available timber resources are extremely scarce and even small pieces have to be imported from elsewhere. Therefore, care is taken to use as many poles as possible (usually larger and thicker than necessary) in order to enhance the longevity of the whole structure and thus reduce the amount of future repairs and/or beam replacements. This is also the main reason why villagers prefer to use hard and durable woods, as for example pine. Descriptions of the roof-building sequence from the same area have indicated that, as a rule, branches and big knots are trimmed first, followed by the peeling of the bark. The resulting poles are used on the roof itself and as upright posts to prevent wall subsidence. Branches, small twigs and/or reed bundles are piled on top of the horizontal poles to provide bedding for the earthen superstructure. The latter may comprise a thick layer (approximately 20 cm) of mud (*toprak*) sometimes overlain by *çorak* (a material much reminiscent of lake marl, rich in mineral salts and very waterproof). Roofs are also built with a slight curvature (achieved through the addition of extra mud layers in their central portion) in order to let rainwater roll over the top surface easier and thus prevent cracks and holes occurring in the dirt packs.

Despite such efforts to ensure the stability and longevity of roof structures, maintenance works have to take place regularly, particularly during the summer months. Soil must be added every year due to its constant removal by rainwater. In the village of Del Koh in western Iran, roof repairs are a constant preoccupation for the local residents; uneven spots and cracks have to be filled in with dirt, whilst persistently leaky spots are dug up, refilled and pressed as soon as possible (Friedl & Löffler 1994). By far, the most important maintenance task is to keep the roof free of snow and to squeeze rainwater out by pulling a heavy oak- or stone-roller on a rope across it. The same authors report the preference of local villagers in the past for oak trees, instead of poplars, for roof construction. The latter became popular only recently, after the widespread introduction of poplar plantations on the banks of irrigation ditches. They also emphasize that conditions of scarcity (including that of fuel resources) have imposed on the local community an ethos of recycling, whereby all material items pass through different phases of use before reaching the ultimate stage of discard, which in the case of wood is represented by its eventual consumption in the household fireplace.

Rare taxa: haphazard collection, preservation bias or avoidance of particular species?

A number of tree and shrub taxa appear very infrequently across the sampled sequence. These include pine (*Pinus*), plane trees (*Platanus*), alder (*Alnus*), fig (*Ficus*), dogwood/cornelian cherry (*Cornus*), chastetree (*Vitex*), maple (*Acer*), caper (*Capparis*), clematis (*Clematis*), and vine (*Vitis*).

Some of these taxa might represent chance inclusions in the archaeobotanical record. Pine seems to be a case in point: it occurs only once and with a single fragment. One possible scenario is its haphazard collection as driftwood from the banks of the Çarşamba river (the possibility of a modern intrusion seems extremely unlikely since no pine trees grow today anywhere near the site). Equally chance finding appears to be vine (note however the uncertainty surrounding its botanical identification).

Capers and chaste trees on the other hand were probably not appreciated much for their burning qualities and/or ease of collection (especially the spiny varieties of caper). Their increased (proportionally speaking) abundance towards the later levels of the settlement might actually be another indication of the progressive impoverishment of the riverine forest and hence the more indiscriminate use of ligneous species. However, since both of them are likely to have grown as small shrubs, it is possible that their under-representation also reflects a preservation bias due to high rates of charcoal loss when burnt.

The same, however, cannot be argued for alder, plane and cornelian cherry/dogwood. There are references in the ethnographic literature (Smart & Hoffman 1988) describing the aversion felt by certain groups (e.g. the Ingalik of Alaska) for the strong red staining of alder sapwood. Apart from this, alder renders very poor firewood even when seasoned. The opposite is true for plane, which gives 'a good heat and lasts well, either green or seasoned. Excellent as kindling' (Boulton & Jay 1946, 112). Zohary (1973) stresses the age-old reverence expressed for plane trees throughout the Near East, in appreciation of the thick shade they provide during the heat of the summer and their association with running waters and springs. The very low frequency of planewood charcoal across the sampled sequence (early/late levels of the South Area and Building 1 in the North Area) suggests that some sort of avoidance taboo was practised concerning the use of its wood as fuel, which probably aimed at the preservation of plane trees as a permanent feature of the riverine landscape.

Cornelian cherry/dogwood (*Cornus*) presents a more complicated case. According to Davis (*Flora of Turkey*, vol. 4, 540–41) and Browicz (1986) both varieties of *Cornus* encountered in central Anatolia (*Cornus mas*, *C. sanguinea*) grow far away from the Konya plain, in the uplands of eastern Taurus and the Lake District. As the natural habitat of *Cornus mas* are described 'warm and sparse broadleaf forests, particularly of oak (*Quercus cerris*, *Q. frainetto*), hornbeam, beech and even alder, more rarely coniferous ones, of fir and pine' (Browicz 1986, 14). On the contrary, *C. sanguinea* may occupy very diverse habitats. At the northern limit of its distribution (the Black Sea region) it frequents moist localities on riverbanks, lakesides and marshes and thrives in shady environments. Conversely, towards the southern end (Syria, Lebanon, Iraq) it may occur on sunny exposed slopes and limestone rocky outcrops (Browicz 1986, 15). Given the absence from the botanical literature of references to *Cornus* from anywhere around or nearby the Konya plain and its overall lack of association with the vegetation formations reconstructed for this area, it would seem likely that it represents a case of imported wood. *Cornus mas* in particular is renowned for its wood properties: heavy, very hard, with narrow rings, elastic and splintery. Furthermore, ethnographic records from North America describe its extensive use for the making of arrow shafts (Browicz 1986, 14; Gordon Hillman pers. comm.). Its extremely erratic presence and low frequencies in the charcoal record (given also its unique concentration with four fragments in the fill of scoop (5292)) might thus indicate the accidental or otherwise burning of imported artefacts. However, one should leave open the possibility that its distribution was very different during the Neolithic; its presence is actually compatible with the pollen record, already discussed above, indicating the expansion in this region of mesic taxa during the early Holocene. To date, no archaeological woodcharcoal sequences from central Anatolia have been studied to the same level of detail as those of Çatalhöyük and Pınarbaşı. Until comparable data sets have been made available from more archaeological sites in this area, it would be very premature to reach definite conclusions on its prehistoric distribution in Anatolia.

The rare presence of charcoal from fig could be attributed to its low attraction as a firewood species for the inhabitants of Çatalhöyük. Although not encountered in the area today, it could have formed part of oak park-woodland and/or riverine native vegetation in the past and thus cannot be considered as an introduced species. Fig wood has been recovered exclusively from the late levels (including Building 1 contexts) whereas charred remains of fig fruits were encountered only amongst the Level Pre-XII assemblages (Chapter 8), which seems to support a pattern of very random collection for this taxon. The same seems to be the case with maple (*Acer*) and clematis (*Clematis*).

Comparison with other sites: the regional charcoal record

Concerning past vegetation, it appears that in their great majority early Neolithic settlements had access to diverse woodland catchments, comprising riverine gallery forests, oak park-woodland and woodland steppe formations. With the exception of Canhasan III (Willcox 1977; 1978; 1991) no other archaeological wood-charcoal assemblages have been examined in detail from Neolithic settlements in central Anatolia. Other sites from eastern Anatolia such as Cafer Höyük, Çayönü (Neolithic), Hallan Çemi Tepesi (Epipalaeolithic / Neolithic) and Aşvan (Chalcolithic / Bronze Age to historic times) have provided evidence for the exploitation of oak forests from the very beginning of the Neolithic (van Zeist & de Roller 1991 / 2; Willcox 1974; 1991; Rosenberg *et al*. 1995). In Aşvan, this pattern reached its peak in the early Bronze Age. During later periods, the progressive deforestation of the area is evident in the substitution of the preferred firewood species (i.e. *Quercus*, Ulmaceae) by spiny and riverine elements (Salicaceae, *Crataegus*, *Eleagnus*, *Ficus*, *Paliurus*, etc.) also supplemented by cultivated trees such as walnut (*Juglans*). Although for most of these sites no details have been published of the relative frequencies of the different taxa present in their assemblages, some local disparities in modes of woodland exploitation are clearly discernible. Hence, in Canhasan III it is possible to trace a preference for juniper, almond and hackberry instead of oak and pine that presumably abounded (especially the former) in the site environs given its location in the upland zone. The majority of the eastern Anatolian sites also seem to have been focusing on the exploitation of oak park-woodland and forest resources at this time. By contrast in Cafer Höyük riverine taxa, particularly willows and poplars, were evidently selected over oak not only as fuel but also for construction purposes (Willcox 1991). A similar pattern is revealed by the more detailed studies of wood charcoal assemblages from sites in the northern Euphrates (Mureybet, Abu Hureyra, Jerf el Ahmar, Dja'ade & Halula). These analyses have also indicated that riverine forests, rather than oak and terebinth-almond woodlands, were preferentially exploited for firewood (Helmer *et al*. 1998; Roitel & Willcox 2000; Willcox 1992b). This pattern is best exemplified in the long archaeological sequence of Abu Hureyra, where the available evidence points to the progressive impoverishment of the riparian forests from the Epipalaeolithic onwards (Roitel & Willcox 2000). Such regional differences in timber and fuel preferences are likely to reflect local disparities in environmental conditions (cf. Miller 2002) and in the strategies pursued for the exploitation of fuel resources.

Concluding remarks

A number of important contributions to our knowledge of the Neolithic environments and fuel / timber exploitation practices in the Konya plain have arisen from the analysis of the wood charcoal macro-remains from Çatalhöyük. Although analysis concentrated on a single site and a sample sequence covering a relatively limited depth of time (hence prohibiting at large the secure evaluation of long-term patterns of vegetation and climate change in the Konya plain), its results offered nonetheless a unique picture of the Neolithic woodland catchments and their ecological interactions with human settlement at a time scale appropriate for this purpose. Future research at Çatalhöyük and other sites in central Anatolia will undoubtedly fill in some of the missing elements in the long-term temporal sequence. Perhaps more importantly, through this study and the analyses of charcoal material from other sites in the area (the hunting / herding campsites at Pınarbaşı: Asouti 2003), it has been possible to demonstrate empirically that environmental (availability of woodland resources) and cultural (settlement economy) parameters are inextricably linked in the ways they may determine fuel selection and exploitation. The complexity of such interactions[2] runs counter to simplistic arguments positing a direct causal link between changes in net resource availability (usually ascribed to climate change) and any observed shifts in the types and quantities of fuel exploited by prehistoric societies (e.g. the 'principle of least effort': for a comprehensive critique see Asouti & Austin in press; Shackleton & Prince 1992).

From a more methodological point of view, the potential of using multiple lines of evidence (including quantitative analysis alongside the detailed consideration of context type, the related archaeological information and the types of activities represented in the archaeological record) for assessing charcoal taphonomy has also been demonstrated. One important implication of this approach is that the (plausibly) correct identification of taphonomic influences on charcoal preservation is of paramount importance for exploring hypotheses about the intensity of firewood consumption, and the overall types and proportions of fuel exploited in the past. It follows that simple measurements such as the seed:charcoal density ratios occasionally used by archaeobotanists as a means for assessing shifts in fuel consumption (e.g. from firewood to dung fuel and *vice versa*: Miller 1985; Miller & Smart 1984) may offer skewed results unless the composite influences of context type, burning environments, discard practices and post-depositional alterations on charcoal preservation have been addressed. It is evident therefore that, in theory at least, the taphonomic status of a charcoal assemblage should be evaluated separately in each case and the results interpreted in the light of the archaeological information available from each site and the types of activities associated with fuel consumption. It is only when the effects of such parameters on charcoal preservation have been sufficiently addressed that archaeobotanical analysis can provide meaningful answers to questions about large-scale patterns of fuel exploitation.

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Notes

1. By contrast other identifications reported by Matthews *et al.* (1996) have been confirmed, such as hackberry/elm (Ulmaceae), chenopods (Chenopodiaceae), deciduous oak (*Quercus*) and willow/poplar (Salicaceae). Based on the evidence obtained from the identifications of charcoal macro-remains, the tentative identification of *Balanites* in micromorphological thin sections (i.e. *Balanites/Tamarix*: cf. Matthews *et al.* 1996; Chapter 19) is also highly dubious. It is more likely that the charred material identified in thin sections represents tamarisk (*Tamarix*).
2. E.g. opportunistic patterns of fuel exploitation resulting in low-intensity impact on woodland vegetation, the case of the hunting/herding campsites at Pınarbaşı, as opposed to more structured interventions through clearance, timber exploitation and seasonal and/or functional variations in fuel use, leading to complex patterns of vegetation change, the case of the permanently settled community at Çatalhöyük (Asouti this volume; 2003).