Cultural and Environmental History in Archaeological Charred Woods from the Khabur Drainage, Upper Mesopotamia

Joy McCorriston

Résumé

Différencier dans l'histoire et les changements du milieu naturel ce qui relève des impacts climatiques de ceux liés aux sociétés humaines a toujours été un enjeu - surtout dans les steppes arides du Proche-Orient où les références paléoclimatiques usuelles (séquences palynologiques, géochimiques et isotopiques) sont rares. Dans les steppes arides du Proche-Orient, les assemblages de charbons de bois collectés dans les sites archéologiques représentent souvent les seuls indicateurs environnementaux disponibles ; ils sont donc importants pour l'étude des tendances environnementales .

Un ensemble relativement restreint d'assemblages de charbons de bois livre ici des informations sur l'évolution environnementale pendant le Troisième Millénaire av. J.-C. dans le bassin versant du Khabur en Mésopotamie. Les résultats traités par Analyses Canoniques des Correspondances (CCA dans le texte) et des Analyses des Correspondances (CA dans le texte) (CANOCO 4.5), montrent que les espèces de bois échantillonnés sous forme de charbons sur les sites peuvent être classées en Steppiques, Ripisylves et Montagnards, classes dont les distributions varient de façon significative dans le temps et dans l'espace.

Il apparaît cependant que les sociétés humaines ont utilisé à la fois des plantes ligneuses à pousse rapide et à pousse lente : les différences entre plantes à maturité lente ou rapide pourraient aussi s'expliquer par des pratiques d'utilisation du sol qui ont varié entre le début et la fin du Troisième Millénaire. Là où les populations ont investi dans des cultures à maturité lente et dans l'horticulture, les investissements sur les sols et sur le long terme sont plus importants, et conduisent à une flexibilité sociale et économique plus faible . Des systèmes emboîtés de propriété du sol et d' exploitation spécialisée hautement inflexibles pourraient avoir été particulièrement vulnérables, même à des changements mineurs du climat comme cela a pu éventuellement être le cas à la fin du Troisième Millénaire av. J.-C en Mésopotamie du Nord.

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INTRODUCTION

In recent years archaeologists and historians have increasingly appreciated the pastoral and agricultural potential of the steppic margins of the Near East and the integral contributions their occupants made to the expansive, interactive flourishing of urban civilization in the Third Millennium B.C., the so-called 'World System'. Archaeological surveys have shown that human activities in the arid margins of the Fertile Crescent were particularly pronounced during the Early Bronze Age (2900-2000 B.C.)[1], when climatic amelioration over the early Holocene (especially increased rainfall) seems to have characterized broad areas of the Near East[2]. In Upper Mesopotamia, the emer-

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1) Summarized by Wilkinson 2000a : 239-240, 2000b ; Geyer and Calvet 2001.

2) Willcox 1999, Wick *et al.* 2003 : 671, Smith 2005 : 88.

gence of huge, Third Millennium urban centers controlling rich, rain-fed agricultural hinterlands was matched by the emergence of specialized pastoralism and production of a pastoral surplus by tribespeople integrated into the political economies and societies of states[3]. In explaining the florescence and collapse of the Third Millennium political economies, it is clear that climate could have played an important role, but cannot be solely determinative of human experience. Similar periods of favorable climate have recurred, notably in the first centuries A.D.[4], with different consequences. Environmental history, a function of climate history and human exploitation history, therefore plays a critical role in explaining why Bronze Age cultures faced crisis in the late Third Millennium. Wood charcoal analyses can provide insight into both climate and human exploitation histories and are especially valuable in regions where paleoclimate proxy records are few. A data set of charcoal from the Third Millennium sites along the Khabur river in northern Mesopotamia's steppic zone shows how cultural and environmental history contributed to the restructuring of settlement at the end of the Third Millennium.

In the steppic margins of the Near East, local environmental histories remain obscure largely due to absence or rarity of local paleoclimate proxy records. Paleoclimate proxy records mostly come from pollen profiles, lake sediments and lake chemistry and speleothems located in distant highland lakes, desert sabkha, and hill caves. Where major climate systems meet, as is the case across Mesopotamia, strengthening of one system historically shifted the boundaries of others – steppic areas may have thus have experienced very different local climate histories from highlands and moister zones of Anatolia, the Zagros, and the Levant. The lack of localized climate sequences distributed across a broad spatial framework makes the evaluation of climate influence difficult to assess through time in Upper Mesopotamia, even as pollen records elsewhere suggest little change[5].

Long term studies (500-5000 years) of climate change and human land use have recently emphasized a cyclical pattern of many cases worldwide, especially occurring at desert margins and arid zones[6]. Although historical details vary, the cycle generally consists of human populations exploiting fragile margins of deserts, depleting local resources, long-term abandonment, and resilience to new conditions[7]. At the same time, contemporary discussion of long-term climate change and especially of global warming[8] highlight the importance of longer-term data sets and trends (hundreds of thousands of years) for understanding the significance of short-term "events" such as the 2100 B.C. "crisis".

This study provides a long-term data set from one of the arid steppes of Upper Mesopotamia to suggest a long-term perspective on climate and human land use *history* and *cycles*. Wood charcoal analysis from a range of archaeological sites also can potentially contribute spatial resolution to single sequence studies from one archaeological center[9]. The wood charcoals analyzed here stem principally from the studies of the Yale Khabur Basin Project and the generous participation by archaeological salvage missions along tributaries and the Middle Khabur river in the 1980s and 1990s[10]. Analysis rests mostly on a 4500-year data set of wood charcoal from 15 sites (about 21 occupations) spread about 100 km along a longitudinal transect from the fertile agricultural plains of the Upper Khabur to the steppe along the Middle Khabur River (Fig. 1). These locations today receive rainfall from about 450 mm per annum in the north (Tell Aqab) to 200 in the south (Tell Mashnaqa). From the beginning of the Third Millennium B.C., the occupations sampled here were those of specialized pastoralists, who apparently occupied large tracts of marginal land[11]. An exception may be the

3) Fleming 2004, Stein 2004.
4) Rösner and Schäbitz 1991 : 85.
5) Bottema and Cappers 2000 : 43; Bottema 1997.
6) e.g. Barker 2002 ; Barker and Gilbertson 2000 ; Fisher and Feinman (eds.) 2005.
7) Redman 2005.
8) Ruddiman 2005 ; Thompson *et al.* 2006.
9) e.g. Deckers 2005.
10) Summarized in Hole 2001 ; McCorriston and Weisberg 2002.
11) McCorriston 1998 ; Zeder 1998 ; McCorriston and Weisberg 2002 ; Lyonnet 2001 ; Kouchoukos 1998 ; Fortin 2001 ; Hole 1999.

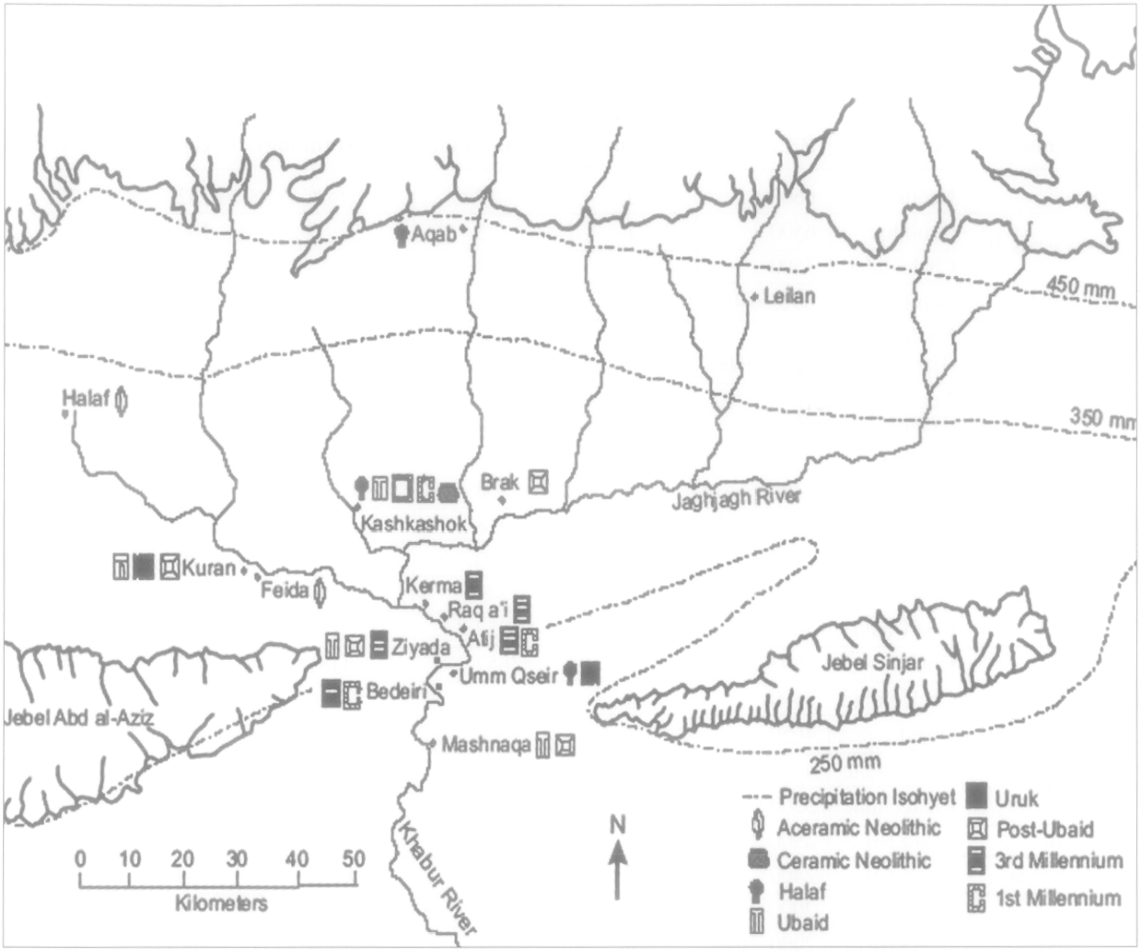

Fig. 1 : Map of the Khabur Drainage Basin with sites and periods.

Middle Khabur site of Tell Bderi with its town wall, planned settlement, and permanent dwellings throughout the Third Millennium B.C. With the inclusion of a few late Third Millennium samples from Bderi, multi-site analysis extends chronologically into the second half of the Third Millennium B.C. (Table 1). The latter samples are nevertheless limited in size and number and offer poor resolution of the 2100 B.C. "crisis". This analysis therefore makes its greater contribution as a long-term background to the 2100 B.C. period of interest.

METHODOLOGICAL ISSUES

The current analysis involves wood charcoal drawn from flotation during excavation and stratified sampling. Identified wood fragments were generally greater than 2mm and included either all fragments in this size range or, where assemblage size permitted, a selection of the 20 largest pieces, usually drawn from a randomly obtained sub-assemblage (taken with a riffle-splitter). Methodological studies elsewhere suggest that fragmentation in wood charcoals favors one species over another[12]. Because the materials studied were highly fragmented (often smaller than 2 mm), weights were chosen for this study. A brief exploratory analysis comparing indexes of weight and fragmentation counts shows that for this data set, the two are fairly compatible, and I therefore chose to use weights to bypass other fragmentation issues, namely the reasonable expectation that fragmentation increases with age (Table 2). The older a piece of wood charcoal, the more friable it

12) Rossen and Olson 1985.

Table 1 : Sites and Periods Included in Analysis.

Site Name	Period Occupied	Date B.C.	Number of Samples	Total Charcoal Weight (in mg)	Identified Charcoal Weight (in mg)	Percentage Identified (weight)	Identified Fragments (Count)
Feyda	Neolithic	6600	2	19	6	32	2
Kashkashok II	Neolithic	6500	1	5	5	100	1
	Chalcolithic	3500	1	54	54	100	2
Tell Halaf	Neolithic	6610-6403	3	391	308	79	33
Kashkashok I	Neolithic (Halaf)	5700/ 5600	2	162	80	49	14
Umm Qseir	Neolithic (Halaf)	5600	2	438	114	26	6
Tell Aqab	Neolithic (Halaf)	5400	2	38	25	66	4
Mashnaqa	Ubaid	5200/ 5000	2	318	118	37	8
	Post Ubaid	4445-4250	11	27,460	5526	20	124
Ziyada	Ubaid	4800-4500	6	1749	697	40	121
	Post Ubaid	4650-4356	6	14,457	3149	22	310
Tell Kuran	Ubaid	4693-4650	5	3657	1181	32	74
	Chalcolithic	3500	5	6989	4060	58	92
Kashkashok III	Ubaid	4650	1	1668	809	49	21
KS 160	Chalcolithic	4190	1	68	52	76	16
Brak Ditch	Chalcolithic	3500	1	138	134	97	20
Tell 'Atij	Jazira I-II	2900-2600	6	16,385	5830	36	128
Tell Judeida	Jazira I-II	2400	7	16,778	14,161	84	86
Tell Bderi	Jazira I-II	2900-2400	2	931	216	23	37
	Jazira III-IV	2400-2100	5	5002	1508	30	98
Kashkashok IV	Parthian/ Hellenistic	250	3	1809	258	14	18
TOTALS			**73**	**81,738**	**38,291**	**47**	**1215**

Table 2 : Exploratory data on average (Mean) fragmentation and weights by period, using classes of Oak (*Quercus* sp.), which is relatively heavy (and scarce), and Willow/Poplar W-P (*Salix/Populus*), which is known to be relatively light.

Period	% Oak by Fragment	% Oak by Weight	% W-P by Fragment	% W-P by Weight	Oak/W-P index by weight	Oak/W-P index by fragment
Neolithic	0.07	0.07	0.07	0.06	1.1	1
Ubaid	0.02	0.02	0.11	0.12	0.16	0.18
Post Ubaid	0	0	0.16	0.22	0	0
Chalcolithic	0.04	0.07	0.08	0.06	1.1	0.5
Jazira I, II	0.03	0.03	0.30	0.30	0.1	0.1
Jazira III, IV	0.02	0.04	0.25	0.25	0.16	0.08
Parthian/Hellenistic	0	0.05	0	0	n/a	0

In later periods, oak (the heavier wood) has not fragmented as much as in earlier periods, thus a measurement differential occurs between percentages of (few) fragments of oak and (greater) weight of oak. This differential is not apparent in a lighter wood such as Willow/Poplar. Earlier and later percentages of Willow/Poplar show that there is no difference whether measured by fragment or percentage. The Oak/W-P index is comparable whether constructed using weight or fragments in the earlier periods, but by the Chalcolithic, the heaviness of (younger, better preserved) individual oak fragments creates a differential in Oak/W-P indexes.

becomes, thus making comparisons between Neolithic and Bronze Age samples using counts (number of fragments identified) at least partly a function of age-related fragmentation[13].

The assemblage of available wood charcoal fragments was often very small, especially for earlier periods. The fragility of materials from earlier samples, thousands of years older and twice the age of later ones, contributed to poor preservation during excavation and flotation. Sometimes only a few identifiable fragments were available and the total weights of identified wood charcoal were very small (average = 0.515 g; median = 0.212 g; standard deviation = 893). A glance at Table 2 shows that oak (a slow-growing, forest/parkland species) was never abundant. It nevertheless occurred in greater proportions in earlier periods and saw a decline over time in contrast to growing percentages of (faster-growing river gallery forest) willow and poplar. This provides an environmental clue to the composition of earlier samples, which were not simply small because they came from sites poor in wood charcoals. There was apparently good hardwood – like oak – available for the burning, but several thousand years between the Neolithic and the Bronze Age took an important toll on buried charcoal, with the result that few fragments greater than 2 mm survive. Another important factor in the small sizes and amounts of wood charcoals is the environmental context of sites, situated in steppe or open parkland environments with limited wood resources and ample evidence of dung fuel use[14]. The results show that many species were shrubs and chamaephytes, difficult to identify and lacking a heavy mass of dense wood that resisted ashing in dung fires. Others have also noted the paucity of wood charcoal remains from steppic sites[15], but even sparse data are critical in zones otherwise devoid of paleoecological proxies.

Of the > 2 mm charcoals, between 9%-100% of an assemblage was identified, with a mean identification rate of 52% (standard deviation=32). Identification was greatly assisted by the author's modern reference collection, compiled in the Jezireh and including woody shrubs, roots, and chamaephytes such as *Teucrium pruinosum* (Sample # 657), *T. polium*, *Dendrostellaria lessertii* (# 604), *Atriplex leucoclada* (# 316), *Artemisia herba-alba*, *Noaea mucronata*, *Hammada eigii*, *Prosopis farcta*, *Capparis spinosa*, *C. carthaginia*. These greatly augment standard reference keys[16] and floras[17] used in identification.

The assemblages contain 23 identifiable genera and 3 additional categories (Chenopodiaceae, tuber/cotyledon, and monocotyledon) (Table 3) Of these, 16 recur in more than 10% of the assemblages and were therefore used in further statistical analysis. With some reluctance, a number of "species" (the term employed in the ecological statistical software used – "species" in this usage includes genera and other taxonomic categories) were dropped from statistical analysis (Table 4). Because many of these genera include only one species potentially growing in the Khabur drainage (e.g., *Acer* sp., *Ulmus* sp., *Atriplex leucoclada*), some would appear on ecological grounds to be very promising proxy data for ancient conditions. Some clearly are exotic (*Pinus* sp.) or domesticates (*Olea* sp.). But their occurrence in the data set is too rare to be statistically differentiated from random. Including these promising genera in statistical analysis obscures underlying patterns in more frequent genera and thereby detracts from formal analysis[18]. These rare "species" were therefore excluded, including *Atriplex leucoclada*, which has a different ecological niche from other chenopod genera obviously present (*Noaea* and *Hammada*) and was therefore not counted with Chenopodiaceae. This exclusion left 13 "species" (genera) and three categories (Table 5).

Statistical analyses reported here include Correspondence Analysis (CA) and Canonical Correspondence Analysis (CCA) included in the CANOCO 4.5 software[19]. These non-parametric multivariate approaches, developed for a wide variety of ecological data sets, are particularly suited to typical archaeobotanical data sets, which are usually unimodal (the relationship between inde-

13) *cf.* Asouti 2003.
14) McCorriston and Weisberg 2002.
15) Miller 1997 : 124-126.
16) e.g., Fahn *et al.* 1986 ; Schweingruber 1982.
17) Townsend and Guest 1966-1985 ; Mouterde 1966-1983.
18) e.g., Jones1991 ; van der Veen 1992 ; Colledge 2001.
19) ter Braak and Šmilauer 2002.

SAMPLE	PERIOD	LATITUDE	TOTAL WOOD CHARCOAL (in mg)	IDENTIFIED WOOD CHARCOAL (in mg)	% IDENTIFIED	*Pinus* sp.	*Acer* sp.	*Pistacia* sp	cf. *Capparis* sp.	CHENOPODIACEAE	*Hammada* sp.	*Noaea mucronata*	*Atriplex leucoclada*	*Artemisia herba-alba*	*Quercus* sp.	cf. *Salvia* sp.	*Teucrium polium/pruinosum*	*Prosopis farcta*	*Ficus* sp.	cf. *Olea*	*Fraxinus* sp.	*Platanus orientalis*	*Amygdalus* sp.	*Prunus microcarpa*	MALAOIDEAE	*Populus*/*Salix*	*Tamarix* sp.	*Dendrostellaria* sp.	*Ulmus* sp.	tuber/cotyledon	monocotyledon
21	NEOLITHIC	691	14	6	42,9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	2
52		691	5	5	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
96		840	123	109	88,6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	109	0	0	0	0	0	0	0	0
95		840	71	71	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	59
7		581	5	5	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0
94		840	197	128	65	0	35	27	0	0	0	0	0	0	0	0	57	0	7	0	0	0	0	0	0	2	0	0	0	0	0
100		581	87	45	51,7	0	0	0	0	0	0	0	0	0	28	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57		409	102	11	10,8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0
58		409	336	103	30,7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	74	0	0	0	0	15
97		581	75	35	46,7	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	26	0	0	0	0	0	0	0	0
202		994	28	22	78,6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	0	0	0	0	0	0	0	0	0
204		994	10	3	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
61	UBAID	298	61	61	100	0	0	0	0	9	0	26	0	0	0	0	0	0	0	0	0	0	26	0	0	0	0	0	0	0	0
37		298	257	57	22,2	0	0	0	0	3	50	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
724		411	5	6	120	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4
640		411	303	108	35,6	0	0	91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	3	0	0	0	5
736		411	15	13	86,7	1	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1
739		411	101	37	36,6	0	0	1	0	0	15	0	0	0	8	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	4
23		692	569	205	36	0	0	0	0	0	0	0	0	188	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
24		692	59	6	10,2	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0
22		692	1094	452	41,3	0	0	0	0	0	0	0	0	63	0	0	0	82	0	0	83	0	0	0	0	91	0	0	0	0	133
25		692	749	79	10,5	0	0	0	0	60	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	8	0	0	0	0	6
28		692	1186	439	37	17	0	39	0	56	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	293	0	0	0	0	17
59		581	1668	809	48,5	0	0	0	0	0	0	0	0	489	0	0	0	48	0	0	90	0	0	0	0	5	177	0	0	0	0
657		411	438	170	38,8	0	0	0	0	11	0	0	0	0	0	0	0	132	0	0	0	0	0	0	0	0	3	0	0	0	24
715		411	887	195	22	0	0	195	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3 : Identified species of wood according to charcoals. Khabur basin, by period and by site. Counting results in weights (mg).

SAMPLE	PERIOD	LATITUDE	TOTAL WOOD CHARCOAL (in mg)	IDENTIFIED WOOD CHARCOAL (in mg)	% IDENTIFIED	*Pinus* sp.	*Acer* sp.	*Pistacia* sp	cf. *Capparis* sp.	CHENOPODIACEAE	*Hammada* sp.	*Noaea mucronata*	*Atriplex leucoclada*	*Artemisia herba-alba*	*Quercus* sp.	cf. *Salvia* sp.	*Teucrium polium/pruinosum*	*Prosopis farcta*	*Ficus* sp.	cf. *Olea*	*Fraxinus* sp.	*Platanus orientalis*	*Amygdalus* sp.	*Prunus microcarpa*	MALAOIDEAE	*Populus/Salix*	*Tamarix* sp.	*Dendrostellaria* sp.	*Ulmus* sp.	tuber/cotyledon	monocotyledon
654	POST-UBAID	411	756	345	45,6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	260	0	0	0	8
604		411	5065	525	10,4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	125	335	0	0	65
71		298	62	27	43,5	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	8	0	0	0	0	8
72		298	91	14	15,4	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73		298	33	12	36,4	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0
75		298	74	31	41,9	0	0	0	0	0	0	0	0	22	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0
76		298	428	110	25,7	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0
77		298	383	45	11,7	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	13
78		298	259	59	22,8	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	46	0	0	0	0
84		298	25897	5036	19,4	0	0	0	0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33	4981	0	0	0	0
712		411	2070	1133	54,7	0	0	0	0	0	0	0	0	0	0	0	222	0	0	0	0	0	0	0	0	22	879	0	0	2	8
603		411	741	102	13,8	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	51	0	0	0	12
723		411	3803	763	20,1	0	0	344	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	46	373	0	0	0	0
685		411	2022	281	13,9	0	0	78	0	0	0	0	0	0	0	0	0	0	0	85	0	0	0	12	0	29	58	0	0	0	19
62		298	110	110	100	0	0	0	0	0	0	0	0	34	0	0	0	0	0	0	0	0	0	0	0	0	76	0	0	0	0
62		298	98	57	58,2	0	0	7	0	0	0	0	0	0	32	0	0	0	0	0	0	0	0	0	0	0	18	0	0	0	0
62		298	25	25	100	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	CHALCOLITHIC	482	68	52	76,5	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	39	10	0	0	1	0	4
11		581	54	54	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	54	0	0	0	0
101		692	138	134	97,1	0	0	0	0	0	0	0	0	0	76	0	0	0	0	0	30	0	0	0	0	17	0	0	0	10	1
27		692	70	35	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31	0	0	0	4
89		692	167	114	68,3	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	58	0	0	14	19	0	0	0	12
90		692	1894	855	45,1	0	0	832	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	12
91		692	958	793	82,8	0	0	726	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	43	0	0	0	0	10
92		692	3900	2263	58	0	0	2263	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3 (Cont.) : Identified species of wood according to charcoals. Khabur basin, by period and by site. Counting results in weights (mg).

SAMPLE	PERIOD	LATITUDE	TOTAL WOOD CHARCOAL (in mg)	IDENTIFIED WOOD CHARCOAL (in mg)	% IDENTIFIED	*Pinus* sp.	*Acer* sp.	*Pistacia* sp	cf. *Capparis* sp.	CHENOPODIACEAE	*Hammada* sp.	*Noaea mucronata*	*Atriplex leucoclada*	*Artemisia herba-alba*	*Quercus* sp.	cf. *Salvia* sp.	*Teucrium polium/pruinosum*	*Prosopis farcta*	*Ficus* sp.	cf. *Olea*	*Fraxinus* sp.	*Platanus orientalis*	*Amygdalus* sp.	*Prunus microcarpa*	MALAOIDEAE	*Populus/Salix*	*Tamarix* sp.	*Dendrostellaria* sp.	*Ulmus* sp.	tuber/cotyledon	monocotyledon
307	JAZIRA 1-2	430	914	253	27,7	0	0	0	0	0	98	6	0	0	0	0	146	0	0	0	0	0	0	0	0	0	0	0	0	0	3
316	JAZIRA 1-2	430	1045	652	62,4	0	0	0	0	0	0	0	203	35	0	0	293	0	0	0	0	0	0	0	0	45	0	0	60	16	9
309	JAZIRA 1-2	430	3117	894	28,7	0	0	0	0	0	0	0	0	0	0	0	201	0	0	0	0	0	0	611	0	0	72	0	0	0	10
305	JAZIRA 1-2	430	5485	2286	41,7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1755	531	0	0	0	0
306	JAZIRA 1-2	430	2658	1143	43	0	0	0	0	24	23	151	0	386	0	0	0	0	0	0	0	0	0	0	0	409	126	0	11	0	13
301	JAZIRA 1-2	430	3166	602	19	0	0	0	0	62	187	0	0	0	0	0	0	10	0	0	0	0	0	0	0	270	73	0	0	0	0
165	JAZIRA 1-2	432	2437	2437	100	0	0	0	0	0	1077	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1360	0	0	0	0	0
166	JAZIRA 1-2	432	2282	2169	95	0	0	0	0	0	0	525	0	0	0	0	0	0	0	0	0	0	0	0	0	1644	0	0	0	0	0
172	JAZIRA 1-2	432	1189	1189	100	0	0	0	0	0	951	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	211	0	0	0	0
172,5	JAZIRA 1-2	432	1167	528	45,2	0	0	0	0	0	399	0	0	0	0	0	0	0	0	0	0	0	0	0	0	76	0	0	0	0	53
173	JAZIRA 1-2	432	1978	1978	100	0	0	0	0	0	47	0	0	0	0	0	0	1645	0	0	0	286	0	0	0	0	0	0	0	0	0
174,5	JAZIRA 1-2	432	4592	2896	63,1	0	0	0	0	0	0	0	0	0	0	0	0	2017	0	0	0	0	0	0	0	879	0	0	0	0	0
180,5	JAZIRA 1-2	432	3133	2964	94,6	0	0	0	0	0	0	0	0	0	1255	0	0	0	0	0	42	0	0	0	0	1410	257	0	0	0	0
39	JAZIRA 1-2	387	344	83	24,1	0	0	0	0	30	0	0	0	0	0	0	11	0	21	0	0	0	0	0	0	7	0	0	0	6	8
41	JAZIRA 1-2	387	587	133	22,7	0	0	4	6	0	0	0	0	0	0	0	39	0	0	0	0	0	0	0	0	74	0	0	0	10	0
45	JAZIRA 3-4	387	2187	581	26,6	0	0	0	0	16	0	0	0	0	0	0	0	0	67	0	0	0	0	0	23	150	316	0	0	9	0
43	JAZIRA 3-4	387	540	95	17,6	0	0	0	0	0	0	0	0	0	18	0	14	0	20	0	0	0	0	0	0	26	11	0	0	4	2
53	JAZIRA 3-4	387	668	132	19,8	0	0	0	0	33	0	0	0	0	0	0	84	0	0	0	0	0	0	0	0	12	3	0	0	0	0
42	JAZIRA 3-4	387	1487	610	41	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	207	388	0	0	0	0	6
54	JAZIRA 3-4	387	120	90	75	0	0	3	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	79	0	0	0	0	0	5
15	PARTH.	581	1462	128	8,76	0	0	75	0	0	0	0	0	22	18	0	0	6	0	0	0	0	0	0	0	0	7	0	0	0	0
14	PARTH.	581	278	120	43,2	0	0	88	10	0	0	0	0	0	0	0	0	0	0	0	22	0	0	0	0	0	0	0	0	0	0
18	PARTH.	581	69	10	14,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0

Table 3 (Cont.) : Identified species of wood according to charcoals. Khabur basin, by period and by site. Counting results in weights (mg).

Table 4 : Taxa excluded from analysis.

Taxa Excluded from Analysis (Occur in fewer than 10% of samples)	Number of occurrences
Pinus sp.	2
Acer sp.	1
Capparis sp.	2
Atriplex leucoclada	1
Salvia sp.	1
Olea sp.	1
Platanus sp.	2
Prunus sp.	3
Dendrostellaria sp.	1
Ulmus sp.	3

Table 5 : "Species" included in Multivariate Statistical Analyses.

Taxa Included in Analysis (Occur in 10% or more samples)	Number of occurrences
Pistacia sp. 20	
CHENOPODIACEAE	11
Hammada sp.	10
Noaea mucronata	4
Artemisia herba-alba	13
Quercus sp. (probably deciduous)	8
Teucrium polium/pruinosum	12
Prosopis farcta	10
Ficus sp.	4
Fraxinus sp.	10
Amygdalus sp.	5
MALAOIDEAE (includes *Crataegus*, *Prunus*, *Pyrus*)	4
Populus/Salix	39
Tamarix sp.	30
tuber/cotyledon	9
monocotyledon	35

pendent and response variables is not linear because the "species" are responding to an optimum combination of "environmental" variables and can be described by a quadratic equation) and contain many missing data (zeros). CA and CCA are rapidly becoming a common standard in Near Eastern archaeobotanical analysis[20] because they are more appropriate than most other multivariate approaches (such as principal component and discriminant analyses). These other multivariate approaches entail assumptions about the structure of data that archaeobotanical data sets typically cannot sustain.

Visualization helps in presenting and reading the results of CA and CCA. A common presentation is the scattergram (CA), which can be read using the centroid principle[21]. In a scattergram of species, each point represents the center (in two dimensions) of the three dimensional distribution of samples containing that species. Fig. 2 shows a clustering of samples containing taxa from the same ecological classes, suggesting that this particular classification of taxa by ecological class (Riverine, Montane, Steppe) indeed reflects meaningful categories of wood. The first (horizontal) and second (vertical) axes of ordination have the greatest explanatory power in the distribution of samples.

Where presenting the results of an analysis (CCA) that evaluates the strength of an "environmental" variable (here geographic location on a north-south axis as a proxy for rainfall, date, or period as a proxy for cultural influence), a biplot rather than scattergram is used and the biplot rule is used in interpretation. The biplot rule is used to connect a species point with the origin point (the crossing point of ordination axes). Samples can then be assessed by perpendicular projection to this line: the distances from the species point at which projected connections cross the species-origin line reflect that species' frequency in the sample[22].

Analysis focused on examining two aspects of the data set of wood charcoal assemblages from multiple locations, dates, and cultural practices. With CA it was possible to explore any major patterns in the "species" data with the expectation that location, date, or different cultures would provide post-hoc interpretive explanations for obvious patterns. CCA was used primarily to identify which variables – location, date, culture – had statistically significant power to explain variability in sample composition. In the basic data set, each sample was assigned a date (quantitative variable) based where possible on direct ^{14}C dating of one charcoal fragment and intercalated from stratigraphy where no direct ^{14}C date was available. As a quantitative proxy for location (related to precipitation), the last three digits of Cartesian geographic coordinates (in decimal format) were used (with a range between 298 at southernmost Mashnaqa and 994 at northernmost Tell Aqab). For culture, a

20) e.g. Colledge 2001, 2003 ; Charles and Bogaard 2002 ; Riehl 1999 ; Smith 2005.
21) ter Braak and Šmilauer 2002 : 414-416.
22) Lepš and Šmilauer 2003 : fig. 10-11 ; ter Braak and Verdonschot 1995 : 270-273 ; ter Braak 1994.

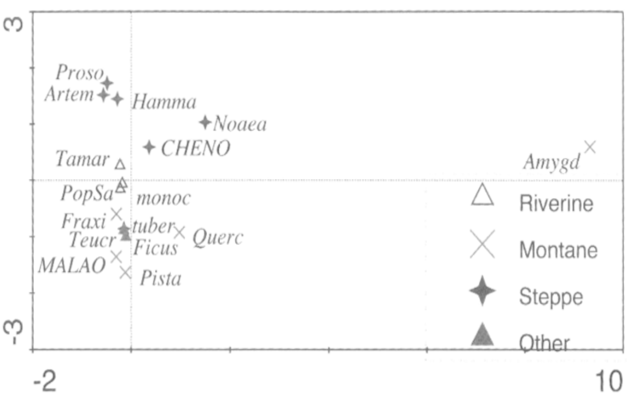

Fig. 2 : CA Scattergram of "species" by ecological class. Note a cluster of "Steppe" species in the upper half of the diagram clearly separates from a cluster of "Montane" species in the lower half by the first (horizontal) axis of ordination. "Riverine" species are separated by the second axis (vertical) of ordination. This diagram suggests that the ecological classification constructed for this analysis by assigning species to "Riverine", "Montane", "Steppe", and "Other" classes reflects statistically significant relationships among the species.

classification (nominal) variable based on associated material culture reflects both cultural and temporal differences (e.g., Neolithic, Ubaid, Post Ubaid, Jazira 1-2, Jazira 3-4, Parthian/ Hellenistic). Because of small numbers of samples, it seemed best to group Pottery Neolithic and Halaf period into a general Neolithic category, while the Third Millennium samples have been grouped according to recent ceramic classifications[23].

RESULTS

CCA: The differing approaches of correspondence analysis and canonical correspondence analysis provide complementary results shown here in Fig. 3 and 4. CCA has constrained the axes of ordination so that the analytical results explain species variability in terms of the indicator (environmental) variables (Fig. 3). The resulting CCA biplot presents the species scores when constrained by all variables of Period, Latitude, and Date, although the latter two have been suppressed for clarity in the diagram, since they do not significantly explain sample variance (Latitude $p = 0.736$, Date $p = 0.234$). Ubaid ($p = 0.09$) and Parthian (collinear nominal variable not fitted) appear, although neither of these significantly explain sample variance (within 95% confidence). It is important to recognize that the biplot is based only on the first two axes of ordination, which in this case explain a low 11 percent of variance in species data and only 51 percent of the variance in fitted species data (Table 6). This is not unusual for abundance data, and there are still useful implications to be drawn from the ordination diagram[24].

From this biplot, which is interpreted using the biplot rule[25], one can appreciate how sample composition varies by period, with a distinct difference between early and late Third Millennium samples. If one draws an imaginary line from Jaz 34 through the origin and another from Jaz 12 through the origin, the points for Malaoideae, *Ficus*, and *Amygdalus* fall much further from Jaz 12 than from Jaz 34 if connected by perpendicular offsets to the specified imaginary lines. Thus samples from Jazira 1-2 differ from Jazira 3-4 in species composition (principally Malaoideae, *Ficus*, *Amygdalus* and *Noaea* and *Hammada*) but are nevertheless similar in riverine species (i.e., *Tamarix*, *Salix/Populus*).

Through a forward stepwise model, CCA shows that some Period classes had significant explanatory power – notably Jazira 3-4 ($p = 0.002$), Jazira 1-2 ($p = 0.002$), Neolithic ($p = 0.004$), Post Ubaid ($p = 0.006$) and Chalcolithic ($p = 0.008$) – for the variability in species composition of samples from sites across a geographical and temporal range. The use of Monte Carlo simulation with 499 permutations allows the species data to be randomly shuffled for 499 trials against which the variance in the original data set was compared. This approach assesses whether the composition of species in the samples can be explained solely through random principles or whether there exist

23) Pfälzner 2001 : 260 ; Lebeau *et al.* 2000.
24) ter Braak and Šmilauer 2002 : 123.
25) Lepš and Šmilauer 2003 : fig. 10-11.

other underlying factors that must account for the variance in species distributions. In the cases of Jazira 3-4, Jazira 1-2, Neolithic, Post Ubaid, and Chalcolithic nominal classes, p-values given above show statistically significant variance in species composition. Date and Latitude do not significantly explain sample variance.

CA: Jazira 3-4, Jazira 1-2, Post-Ubaid, and Chalcolithic samples have been plotted on a CA scattergram to explore variability in species composition (Fig. 4). On Fig. 4, properly interpreted using the centroid principle, ordination axes 1 and 2 account for 28 percent variance in species data (all four axes account for 48 percent). The first axis separates Jazira 3-4 samples and most of the Chalcolithic samples. Because there is an arch effect, the second axis does not express new information (*i.e.*, the second separation of Post Ubaid and Chalcolithic)[26]. Fig. 5 shows the results of the same CA ordination and should be viewed with Fig. 4; in the case of Fig. 5, pie diagrams for each sample indicate that greater components of Montane species along with *Ficus* and tuber (= Other) separate Jazira 3-4 and Chalcolithic samples from the Jazira 1-2 and Post Ubaid samples dominated by Steppe and Riverine species. A third scattergram (Fig. 6) identifies the samples by site (three sites with one sample each for these periods have been suppressed for clarity), suggesting that site-specific factors may contribute significant variance in species composition. Bderi separates from Atij on axis 1, Ziyade and Kuran on axis 2. Mashnaqa (with a wide spread of samples) has more than one period represented in this analysis. Since the locations of samples are the same on all three scattergrams, one can readily glance among them to gauge species composition, site origin and period for particular samples.

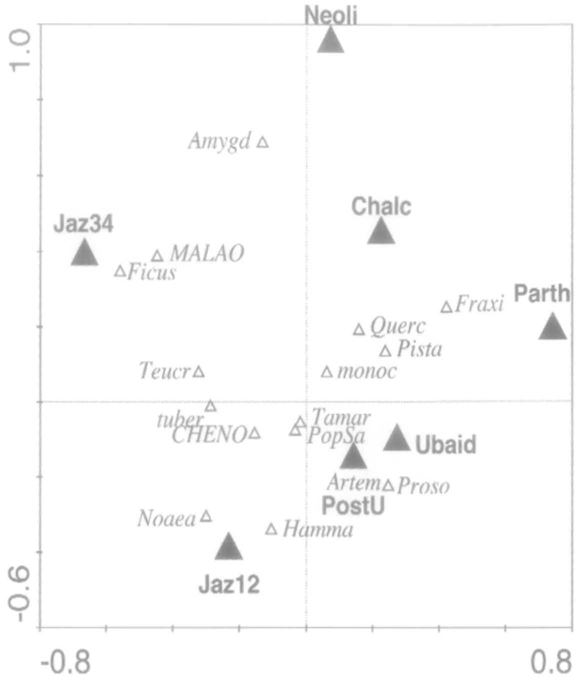

Fig. 3 : A CCA species-environment biplot shows the weighted averages of species scores with respect to (all) environmental variables. (Quantitative variables "Latitude" and "Date" were suppressed from this graph because forward stepwise selection of variables showed these were not significant in explaining variance in species data). Scores for Period classes Neolithic through Parthian are represented as points because these are nominal data best displayed as centroid points (ter Braak and Smilauer 2002 : 168-169).

Table 6 : CCA Summary results from Khabur Wood data set. All four eigenvalues are canonical and correspond to axes that are constrained by the environmental variables.

	Axis 1	Axis 2	Axis 3	Axis 4	Σ canonical eigenvalues
Eigenvalues	0.252	0.229	0.168	0.147	0.948
Species-Environment Correlations	0.770	0.692	0.651	0.589	
Cumulative percentage variance of species data	5.8	11.0	14.8	18.2	
Cumulative percentage variance of species-environment correlation	26.6	50.7	68.4	83.9	

26) ter Braak 1995 : 105.

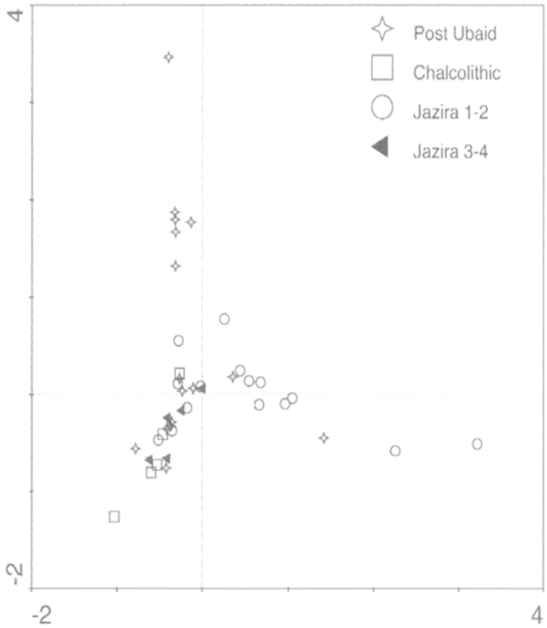

Fig. 4 : CA Scattergram of samples coded for Period. Neolithic samples (with statistically significant variance) were not included in this CA because their removal gives a better view of the relationships among samples from later periods.

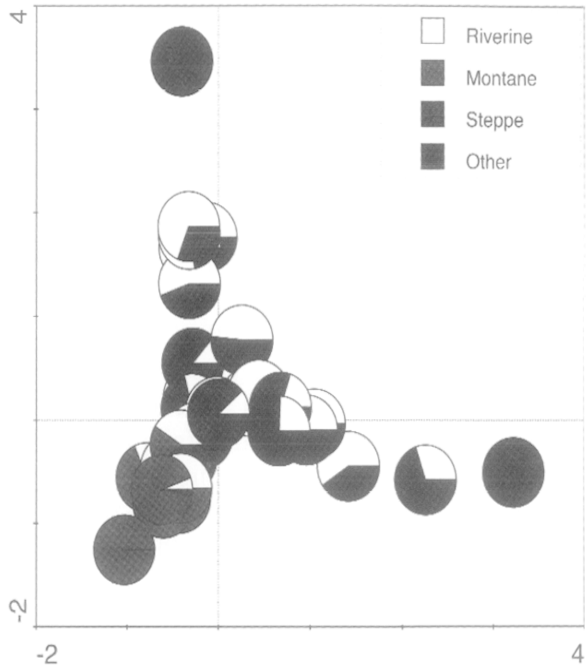

Fig. 5 : CA Scattergram of samples as in Fig. 3 but each sample point shown depicted as pie values for species composition by ecological class. Compare with Fig. 3 to see the composition of samples from different Periods.

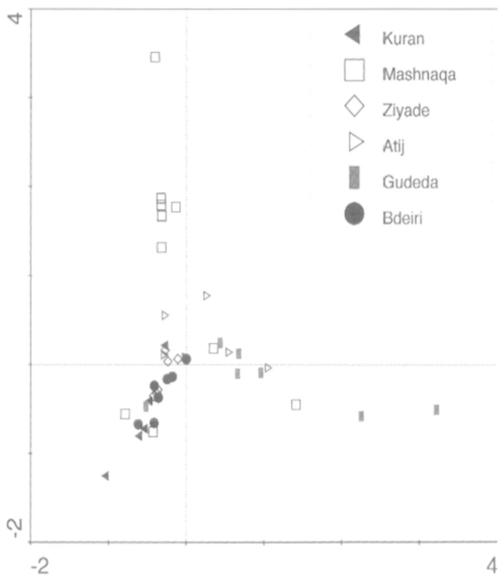

Fig. 6 : CA Scattergram of samples as in Fig. 3 but each sample point coded for site. Note that some sites – notably Mashnaqa – have more than one period represented in the sample set, accounting in part for the wide spread of site points. Compare with Fig. 3.

DISCUSSION

While it might be possible to refine analysis by the re-classification of ecological taxa or periods, addition of other variables, and of course, addition of more samples, the current analysis gives encouraging insight into environmental and cultural processes underway at different times in Northern Mesopotamia's marginal steppe zone. Some of these refinement issues deserve further discussion with the results of CA and CCA.

Ecological classification and the taxa from the Khabur Basin: Fig. 2 indicates that a relatively coarse ecological classification scheme differentiating Riverine, Montane and Steppe classes from a catholic "Other" class (*Teucrium* and *Ficus*) provides largely satisfactory separation of species' points. Axis 1 separates Steppe species from Montane species and Other species, while Riverine species (and Other species) are constrained by axis 2. There remain several ecological factors deserving closer examination. The position of *Amygdalus* (wild almond) on the graph – a clear outlier – may be related to the influence of an outlier sample (#61) or may reflect arbitrary classification of *Amygdalus* among the Montane species. In the latter case, the author and others[27] have noted the aridity tolerance of wild almond, which can, where protected from overgrazing, penetrate deeper than other Montane species into otherwise steppic zones along the seasonally dry wadis that drain mountain areas. Therefore *Amygdalus* probably appears in both steppic and montane zones, more so than other aridity-tolerant plants like *Pistacia*.

Similarly, *Teucrium* presents a problem in interpretation. In the modern Khabur river basin, the *genus* distribution today includes two species: *T. pruinosum*, found in lightly-grazed steppe and lower montane slopes, higher moisture, and slightly deeper soils, and *T. polium*, (Arabic *da'ja*) responding to moderately-heavy grazing and used medicinally by modern pastoralists. Species overlap in habitat is not uncommon. Among the ancient charcoals, it was occasionally possible to differentiate *T. pruinosum*, but nearly all specimens could only be identified to *genus Teucrium*. Therefore the relatively frequent presence of *Teucrium* offers inconclusive and tantalizing clues to its possible uses and environmental origin(s). Both species are highly aromatic, like many other herbs in the Labiatae family, and *da'ja* in particular has been traditionally used in cooking and medical treatment of humans and caprines. As firewood, it would be available among other chamaephytes in the steppe (with which *Teucrium* has been classified in this analysis), but its position on the Fig. 2 scattergram suggests that ancient charcoal comes principally from *T. pruinosum* growing in montane and parkland cover.

Ficus also presents a problem in classification, since it may belong to wild and domesticated species, both of which could have been accessible to ancient occupants in the Khabur[28]. *Ficus* today survives as a wild element (*F. carica* var. *rupestre*) in the southward-draining finger wadis and karstic sinks south of Jebel 'Abd al-'Aziz and only where it is protected from grazing. Of course it can also be cultivated in its domesticated form (*F. carica* var. *carica*) along the Middle Khabur if protected from the harshest of the Jezireh winter winds. It is very possible that unidentifiable small fragments of parenchymous material assigned to the taxon "tuber" come from the parenchymous bands distinct in xylem tissue of *Ficus*.

Monocotyledon fragments almost certainly came from river reeds (*Typha domingensis*) because cereal culm fragments were carefully removed from wood charcoal assemblages and analyzed with crop-processing remains[29]. In several of the Bderi samples (#41 Stratum 25 and #45 Stratum 13), monocotyledon fragments (clearly not reed) resemble *Phoenix* sp., but the total count is small (n = 4). The most convincing sample (n = 1) is from the late Third Millennium, recalling Deckers's[30] arguments that date palms were cultivated along the Middle Euphrates. Significantly, an independent analysis of 37 unfloated samples (with larger charcoal fragments) from Bderi established the

27) Gordon Hillman, Youssef Barkoudah, personal communications.
28) See also Deckers 2005 : 162, Table 5.
29) McCorriston and Weisberg 2002.
30) Deckers 2005 : 164.

presence of most woods reported here, including date palm (*Phoenix dactylifera*) and domesticated fig (*Ficus carica*)[31].

The case of *Teucrium* suggests another interpretation of the significant separation of species classified as Montane and Steppe and the positions of *Teucrium* and *Ficus* on the Fig. 2 scattergram. While the terms used in the classification chosen here reflect modern geographical habitat separation, it is also the case that species in the Montane class – wild pistachio, oak, ash, cherry, hawthorn, wild pear, and almond – all come from relatively slow-growing trees and bushes that produce slow-burning hard wood. In short, where present in archaeobotanical samples, the Montane class may well reflect the collection of mature hard woods from a parkland cover that extended well into the steppe because of a) greater, more reliable, and longer seasons of rainfall than today, b) low grazing pressure on seedlings, or c) a greater availability of spate-water debris or driftwood from flooding, or d) a combination of those factors. *Ficus* and *Teucrium pruinosum* would both fit well into such mature parkland cover. In contrast, the species assigned to the Steppe class – sagebrush, various chenopods, thorny *Prosopis*, and (possibly misclassified) *da'ja* – come from fast-growing chamaephytes that may replace hardwoods in a parkland-steppe ecotone when grazing pressures increase and precipitation declines. Therefore, the relatively clear separation of Montane and Steppe classes in Fig. 2 might be more closely reflective of human ecological practices (grazing, stripping trees, firewood sources) than of modern plant geography implicit in the class names. To better understand this difference, one must consider correspondence of species composition and cultural patterns in the samples.

Non-significant variables: Latitude as a proxy variable for site environment had poor explanatory value, for which there may be several explanations. One is that site environment and environmental availability of different woods are not closely correlated to the single index chosen (Latitude), and that in a future analysis, a wider range of proxies such as modern precipitation, reconstructed precipitation (for the time occupied), distance from standing/flowing water, elevation, and local soil-type(s) should be included. In Fig. 6, the clustering of samples from different sites suggests that site-specific conditions may affect sample composition, but such differences alone seem unlikely to account for the clear separation of samples from Atij and Ziyada, a few kilometers apart on the Middle Khabur. Another distinct possibility, and one that can be substantiated from this analysis, is that cultural preferences and practices at least to some degree override the influence of local environment (latitude) because people choose particular woods for particular purposes, selecting one category over another even if the latter is more abundant.

Like Latitude, Date also provided no significance in explaining variance in sample composition. Once again, there may be problems with the index variable – samples may have been inadequately dated through association with a single ^{14}C-dated specimen (which was almost never included in this analysis) or inaccurately assigned by association with ceramic types in middens that accumulated through hundreds of years[32]. On the other hand, if cultural preferences and practices account for some of the sample variance, a close correlation to date would only be expected in the case of one long-term cultural trend, clearly not the case when one considers other archaeological data sets from the Syrian Jezireh, which include periods of near complete site and region abandonment. Other variables that could account for variance in species composition across samples could include formation processes, sample context, and sample recovery methods, some of which have been considered for these sites[33] and elsewhere[34]. The contributions of these variables probably would boost the cumulative percentage variance of species data explained through CCA (Table 6).

Period classes and cultural uses of wood: The variance within Neolithic samples (Ceramic Neolithic and Halaf grouped together) so differed from other period classes that the Neolithic data set was suppressed from further analysis. This approach curtailed the periods under consideration to

31) Engel 1996.
32) See McCorriston and Weisberg 2002 for discussion of dating issues.
33) McCorriston and Weisberg 2002.
34) e.g. Smith 2005 ; Asouti 2003, 2005.

the Post Ubaid through Jazira (*ca.* 4400-2100) as dated by Hole[35] and Pfälzner[36]. The resulting CA analysis shows distinct differences among the periods in the composition of wood charcoal samples, suggesting that people's cultural practices varied by period. While they may have been influenced by the environmental availability of different woody taxa, the availability of woody taxa was not determinative of cultural practice. People may have traveled far, brought in wood, or burned rare taxa to provide preferred fuels for different purposes.

The data point to site-based and period-based cultural factors in the use of wood. The later Third Millennium (Jazira 3-4) occupants within the town at Bderi, occupied until 2100 B.C., discarded significantly greater proportions of dense, slow-growing, slow-burning woods like oak, wild pistachio, wild pear or cherry, woods that grew in nearby Jebel Abdalaziz and required transport or provisioning systems to the riverside town. The data also hint at the presence of domesticated fig and date palm, echoing findings at late Third Millennium sites along the Middle Euphrates[37]. For further understanding of the cultural patterns that affected wood collection and use, one must turn to other archaeological data sets in the Khabur.

From settlement patterns[38], the internal analyses of settlement structure[39], and a combination of zooarchaeological and archaeobotanical data sets[40] archaeologists have established that the early Third Millennium (Jazira 1-2) saw an explosion of settlement along the margins of the largely abandoned (late Fourth Millennium) Khabur river in the steppic zone. Many conclude that these small sites, often rich in granaries and storage structures, served as anchors for semi-sedentary populations practicing specialized pastoralism[41] with supplemental feed from barley cultivation, a scenario not incompatible with the identification of trading *entrepôts* and barley shipments along the Middle Khabur[42]. In the later Third Millennium, Jazirah 3-4 period, most of these communal storage facilities had been abandoned while fortified sites along the river like Bderi oversaw trade routes and maintained contacts with the redistributive economies and exchange systems of nearby cities.

A shift from communal to household storage in tandem with the development of redistributive economies as identified by Pfälzner[43] has important implications for cultural uses and approaches to wood and woody resources. Wood may be used as fuel, construction timbers, and may derive (like date palm and fig) from orchard crops that reflect investment and delayed returns. The presence of long-lived hardwoods from montane habitat mirrors the long-range transport system for other commodities – textiles, precious stones, metals – argued to play important roles in the maintenance of complex social systems. Wilkinson[44] argues that route maintenance can be seen in the fortified paired-tell river crossings occupied continuously even as settlements declined through the Second Millennium. Hardwoods for construction timbers were transported long distances even if timber did not constitute the primary reason for routes[45], and their eventual decay and incorporation into fuel debris shifts the latter Third Millennium assemblages from a local environmental signal of only short-lived steppe and riverine species.

In the early Third Millennium when pastoralists practiced communal storage (and by inference, corporate access to resources such as grazing lands, agricultural fields, water, and fuel resources), one can infer that local slow-growing woods in the gallery forest – elm, plane) were quickly depleted through "the tragedy of the commons[46]". Cultural constraints such as sacred trees and injunctions against cutting live wood could mitigate depletion of hardwoods, but the presence of large numbers

35) Hole 2001.
36) Pfälzner 2001 : 260.
37) Deckers 2005.
38) Monchambert 1993, 1994 ; Röllig and Kühne 1983, 1977/1978 ; Lyonnet 2001.
39) Pfalzner 1997 ; Schwartz 1994.
40) Zeder 1998 ; McCorriston 1998 ; McCorriston and Weisberg 2002 ; Colledge 2003 ; Charles and Bogaard 2002.
41) McCorriston 1995 ; Hole 1999 ; Kouchoukos 1998.
42) Fortin 2001.
43) Pfälzner 2001.
44) Wilkinson 2000a : 235.
45) Lebeau 1990 : 250.
46) McCay and Acheson 1987.

of goats and sheep, flocks sufficiently numerous to warrant foddering as a supplement to local grazing[47], would prevent the maturation of seedlings. Fuels were procured locally from short-lived species like willow, poplar, and steppe chenopods. It may have been the success of early Third Millennium specialized pastoralism, propelled by the opportunity of an unusually and consistently moist steppe[48] and manifested by settlement along the Khabur river and *Kranzhugel* in the open steppe[49] that triggered anthropogenic demise of hardwoods and a restructuring of access to them in the latter half of the Third Millennium[50].

The evidence from Bderi wood charcoals[51] suggests that during the Jazira 3-4 period, orchard crops were maintained. Fruit trees require lengthy investment – land, water, pruning, pollinating, defending – before they mature and produce. Such investment for delayed returns typically triggers narrow access rights and ownership[52], an interpretation highly compatible with the documented shift to household storage patterns in Jazira 3-4[53]. Investment in restricted ownership resources probably narrowed the social networks that could provide resilience and flexibility in the face of climatic or environmental crises.

Culture history and cultural frameworks profoundly influence the composition of archaeological wood charcoal assemblages. While the steppe may actually have been more moist during the Third Millennium until climate crisis struck at 2100 B.C.[54], cultural factors of social and economic organization both structured people's access to wood and imposed constraints that conditioned response and recovery from climatic or environmental circumstances. Without a clear understanding of social access to resources, supply routes, and regional integrated economic systems that constrain selection of environmental resources, wood charcoals offer poor or no information on local environmental processes. But when cultural patterns, such as the development of specialized pastoralism in the Third Millennium steppe, can be understood, the anthropogenic signal of resource depletion (local hardwoods like almond, elm, plane trees) in the early Third Millennium and subsequent distance transport of hardwoods and protection of orchard crops can be discerned. A shift away from long-term investment in orchards and the social frameworks that supported them must be factored into broader explanation of the end of the Third Millennium "crisis".

CONCLUSIONS

In conclusion, there were significant differences in the composition of wood charcoal assemblages from the early and late Third Millennium B.C., with a clear increase in slow-growing montane hardwoods and orchard crops (date and fig) in the latter half of the Third Millennium B.C. These patterns in turn differ significantly from assemblages of the earlier periods and, interpreted within the framework of other archaeological data sets, reflect the regional economic integration and provisioning systems of the Third Millennium that ultimately contributed to a case of human populations exploiting the fragile margins of deserts, depleting local resources, long-term abandonment, and resilience to new conditions. Such cycles have been identified worldwide and differ in their historical details, and the Khabur Basin provides another case.

47) McCorriston and Weiberg 2002 : 495 ; Charles and Bogaard 2002 : 326.
48) Hole 1997.
49) Kouchoukos 1998.
50) See also Wilkinson 2000b : 20-21.
51) See also Engel 1996.
52) Acheson 1987 ; Alvard and Kuznar 2001 ; Netting 1982.
53) Pfälzner 2001.
54) Courty and Weiss 1997.

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