Short contribution

Agropastoralism and archaeobiology: Connecting plants, animals and people in west and central Asia

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One of the more intractable problems that archaeobiologists struggle with is how to characterise ancient subsistence systems when the plant and animal remains that we study are incommensurate in so many ways. Three examples from the upper Euphrates and Iran illustrate how changes in plant remains are associated with changes in animal exploitation. Two of them consider the agropastoral continuum on sites dating to the pre-pottery Neolithic (eighth to sixth millennium BC) and to the Chalcolithic and Bronze Age (fourth to third millennium BC) in the dry-farming zone along the Euphrates. The third example considers how changes in woodland allow one to infer the presence of pastoralists in the southern Zagros even in the absence of nomad campsites.

Keywords: Archaeobiological analysis, Agropastoral systems, Ratios, Anthracology, Seed analysis

One of the most important projects for a unified archaeobiology is to elucidate the connections between people, plants and animals. Although our specialised technical expertise requires us to separate the study of floral and faunal remains, we know that ancient people shared their environment with all kinds of living things, especially in the agropastoral systems of west and central Asia. Whether a society emphasises agricultural or pastoral production depends on many factors that are amenable to archaeological investigation, such as human population densities, mobility and climate.

The first problem is to identify points where the exploitation of plants and animals intersect, and the second is to identify the relevant archaeological evidence. This contribution will give some examples using macrobotanical and faunal remains. Increasingly, microscopic and biomolecular methods are supplementing the more traditional methods. For example, phytolith concentrations associated with dung deposits provide information about foddering practices and local floras (e.g. Albert *et al.* 2008), and at Gordion, Turkey, residues of a stew made of caprine meat and pulses highlight the way a cuisine may use both animals and plants (McGovern *et al.* 1999).

Of necessity, archaeobiologists treat plant and animal evidence differently. The nature of the organisms themselves demands different kinds of quantification. Also, there are more plant taxa than animal taxa, and where any particular animal has a fixed number of bones, plants produce indeterminate numbers of seeds. Preservability and depositional processes are also important. Plant parts are most likely to be preserved when they are charred, though any circumstance that reduces biotic activity, such as burial in dry or waterlogged conditions, can provide complementary evidence. Bones are adversely affected by acid soils. Plant and animal remains follow different paths to their final resting places in archaeological sites: charred plants are likely to be spent fuel, crop-processing debris, or the remains of burnt structures and food stores, where bones might be the discards of food preparation or remains of deceased commensals such as mice. Identifying and quantifying the remains requires different kinds of expertise. Sampling and recovery are very different, too. It is a bit of a fiction, but with screening, you can arguably say that you have collected all the bone and big pieces of wood charcoal from an excavation. But seeds and wood in flotation samples necessarily come from a relatively small proportion of the excavated deposits.

All of this has very important implications for integrated analyses of plant macroremains and animal

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DOI 10.1179/1749631413Y.0000000003

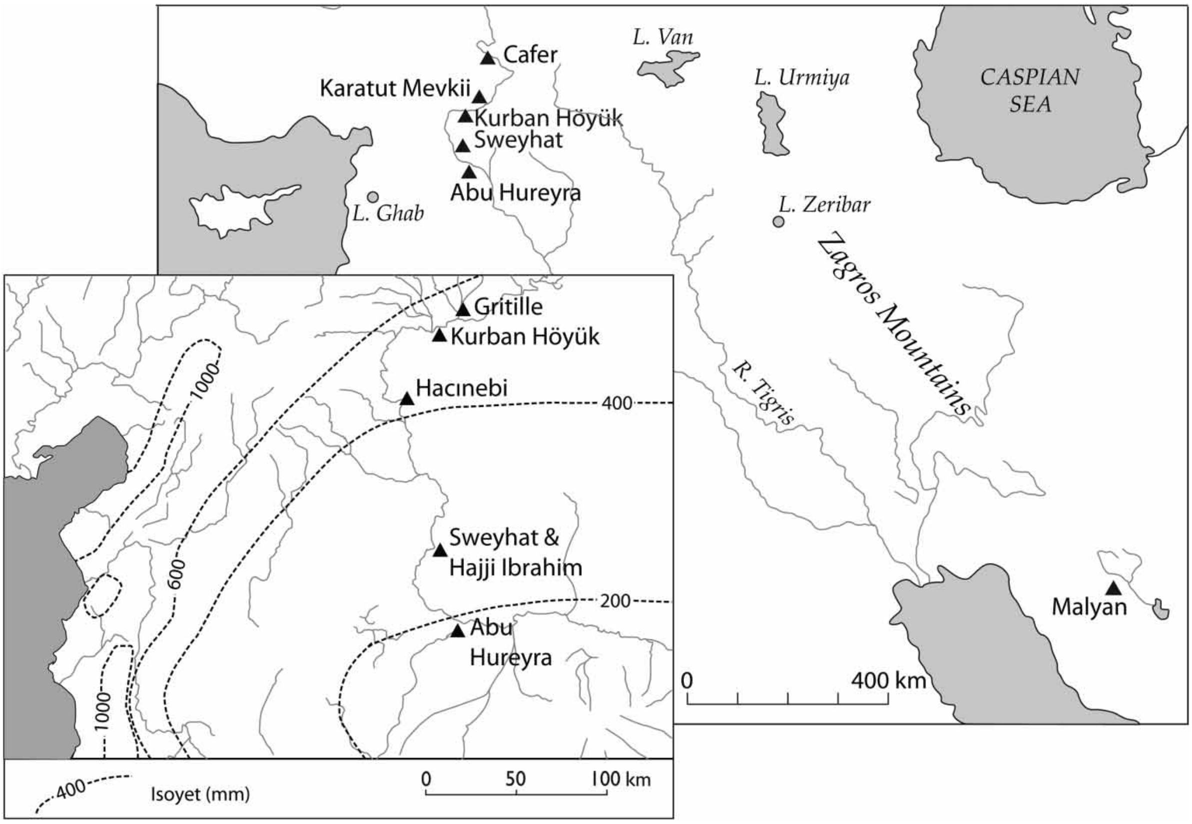

Figure 1 Map showing sites discussed in the text. Inset source: Willcox *et al.* (2008).

bones. The agropastoral system does leave traces in phase-to-phase changes across a site or across a series of sites, as Smith and Munro (2009) have shown for northern Syria and Klinge and Fall (2011) for several sites in Cyprus and the the eastern Mediterranean. Such patterning rarely can be distinguished with small numbers of samples, and there are many ways to organise archaeobotanical data. Ratios and percents are useful because they isolate particular variables of interest and they are very easy to understand (Miller 1988; Miller and Marston 2012). This contribution illustrates this approach with three examples of how changes in plant remains are associated with changes in animal exploitation (Fig. 1). The first two examples consider the agropastoral continuum on sites dating to the pre-pottery Neolithic (eighth to sixth millennium BC) and to the Chalcolithic and Bronze Age (fourth to third millennium BC) in the dry farming zone along the Euphrates. The third example considers how changes in woodland allow one to infer the presence of third millennium BC pastoralists in the southern Zagros even in the absence of ancient campsites. All plant remains included in the discussion are charred.

Methodological issues

It comes as no surprise that archaeobotanists work with less than perfect data sets. Many assemblages are small, and even substantial ones typically exhibit large within-site or within-phase variation. Some samples may be characterised as nearly pure seed remains and may be useful for confirming that a particular type was a crop, or at least intentionally collected. Other samples are heterogeneous, and come from hearth rakeouts or other accidentally charred occupation debris. For questions concerning the remains of daily activities, it is better to include just occupation debris and exclude crop deposits.

The basis of interpretation is some kind of quantitative analysis, but the sampling process (non-random) and assemblage variability require that comparisons across time and space include supporting arguments about the relevance of the quantification choices presented. Ubiquity measures are commonly and successfully used for broad comparisons between sites and phases (see Hubbard 1975). A variety of measures based on sample contents (e.g. number of wild seeds; estimated number of wheat grains) can address specific questions, but many samples will have few or none of the item, and a few samples will be full of material. It is not easy to decide whether each sample should be given equal weight, or if richer samples should count more.

Ratios are one kind of commonly used measure that can be constructed to help characterise assemblages in a quantitative way. Unfortunately, the denominator must be greater than zero or the sample cannot be included in the analysis. At least in west Asia, pulses and cereals were important food crops, but their remains may be absent in otherwise rich samples. To avoid omitting important samples from an analysis, it is common to sum the items of interest for the numerator and the denominator (e.g. wheat-to-barley ratios). That is hard to justify on statistical grounds, but at least it allows one to take quantities of a taxon, not just frequencies, into account. Its effect is to give more weight to the denominator variable (Miller 1988). In many cases, a particular ratio can be constructed for all or nearly all samples (e.g. ratios of seed to charcoal or of wild seed to cereal). Although I used to compare the mean averages of such ratios from site to site or phase to phase, the underlying values in sites I have analyzed are not normally distributed; much archaeobotanical data skews left (that is, most samples have low values for a given measure, but a few have very high ones). The median tends to have a lower absolute value, but follows the same trend as the mean (see, e.g. Miller 2010, table 5·11). So, even though either measure would support a similar conclusion, the median value characterises an assemblage without giving undue importance to atypically large samples.

The data sets I discuss here do not permit definitive interpretation, because the number of samples and the amount of recovered remains are not great. Rather, these examples illustrate a useful way to generate broad comparisons over time and space that can be tested and refined with additional data. As a practical matter, I consider results reasonably secure if multiple lines of evidence point in the same direction and if the analysis of a few more samples is unlikely to add significant new types or change a pattern, as discernible, for example, with cumulative frequency graphs (Green 1979; see Lyman and Ames 2004 for zooarchaeological examples). Especially for botanical remains, absolute numbers are less interpretable than relative amounts or the direction of changes across time and space.

Early Farming along the Euphrates

The Pre-Pottery Neolithic B (PPNB; or Aceramic Neolithic) period designates the time when the diverse experiments in plant and animal domestication came together, creating the flexible agropastoral subsistence base of west Asia (for overview, see Asouti 2006). By the beginning of the PPNB, west Asia was populated by cultivators who lived in villages year-round. The cultivation of cereals and pulses had already resulted in their domestication (Willcox *et al.* 2008). Zooarchaeologists have shown that sheep and goat were morphologically wild at the beginning of the period, and domesticated by the end. More detailed metric analyses and population studies show how changes in herd management practices preceded morphological change during this time (Zeder and Hesse 2000; see also Conolly *et al.* 2011). Thus, the PPNB saw a shift in human–plant–animal relationships through the creation of the agropastoral niche (see Smith 2007).

Table 1 Data from Aceramic (PPNB) sites along the Euphrates

	Approximate date, cal BC	No. of samples	Wild seeds	Cereals	Pulses
Cafer III	8300–8000	33	378	168	206
Cafer II	8000–7500	16	48	102	13
Cafer I	7500–6500	13	292	269	10
Gritille, Earlier	75700–6200	32	704	1·14 g	2·11 g
Gritille, Later	6200–ca. 5000	17	2159	1·94 g	0·48 g
Abu Hureyra 2A	8500–7500	38	6459	460	50
Abu Hureyra 2B	7500–6000	44	6415	521	85
Abu Hureyra 2C	6000–5500	9	921	447	13

Data, dating sources: Cafer (de Moulins 1997; Helmer 2008); Gritille (unpublished laboratory notes, Miller 1999; Mary Voigt, personal communication); Abu Hureyra (de Moulins 1997; Moore *et al.* 2000, 257).

Zeder (2012, 247) points out that human sedentism during the preceding Epipaleolithic and Pre-Pottery Neolithic A periods did not directly lead to uniform, adverse effects on hunting in the vicinity of settlements. Over the course of the PPNB, however, hunting as a source of meat declined relative to animal husbandry over much of the Near East (Zeder 2011) and the magnitude of change in the human–land relationships was greater than it had been before. The end result was the establishment agricultural economies based on plant and animal domesticates (Miller 2011, 68–69; Zeder 2011). The later Neolithic did see a temporary reversion to hunting in parts of Syria (Zeder 1994), which demonstrates the flexibility of the ancient subsistence pattern.

Archaeobiological remains from Cafer, Gritille and Abu Hureyra, located in the dry-farming zone of northwestern Syria and southeastern Turkey span the development of the PPNB agropastoral system (Table 1). Today, annual precipitation is lowest at Abu Hureyra and highest at Gritille.[1] With regard to the process of animal domestication: The Cafer caprines are morphologically wild, but detailed analysis of the assemblage supports the view that at herding was practiced (Helmer 1988, 2008). Those from the early phase at Gritille are wild but the later phases see morphological changes (Stein 1989). Similarly, morphological evidence of caprine domestication is absent in the bones from Abu Hureyra 2A or 2B,

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[1] Modern precipitation is a guide to relative moisture availability in the past, though the actual amounts are different. Annual precipitation at Abu Hureyra is less than 200 mm; at Gritille it is around 550 mm, and at Cafer, between Elazığ and Malatya, it is probably about 400 mm. This estimate is based on records of 432 mm at Elazığ and 382 mm at Malatya (Meteoroloji Bülteni 1974).

but caprines largely replace gazelle in the assemblage by 2B, which suggests that the process of domestication had begun (Legge and Rowley-Conwy 2000).

We may ask, do archaeobotanical data give any further insight into the development of the agropastoral economy? Without domesticated animals, the earliest sedentary plant cultivators faced two critical problems. The first one was maintaining soil fertility while living in permanent settlements and cultivating immovable fields. The second problem was obtaining enough dietary protein and fat, especially if, relative to population, wild game populations declined in the immediate neighbourhood as field clearance permanently changed the character of the vegetation cover.

Cultivating pulses, like lentil, grass pea and bitter vetch, solves both problems. From a fertility perspective: where cereal cultivation depletes soil nitrogen, pulse cultivation replenishes it. From a nutritional perspective: the Near Eastern crop complex of pulses and cereals provides complete dietary protein. Before agriculture, pulses were at least occasionally collected for food. Hayonim cave, one of the few such sites in the Levant, yielded many *Lupinus* seeds (Hopf and Bar-Yosef 1987). Concentrations of pulses become more common under cultivation. For example, early PPNB chickpea and fava bean have been found in northwest Syria (Tanno and Willcox 2006). Fat could come from plant sources like cultivated flax and tree nuts. Pulses served as both food and fertilizer in the context of 'intensive mixed farming' that also included the cultivation of cereals and increasing reliance on caprine herding as inferred for the PPNB peoples of west Asia (Bogaard 2005).

To get the full nutritional benefit of pulses and cereals, they have to be cooked. Before the invention of pottery, the repertoire of PPNB plant food processing and cooking techniques included the use of fire pits. Therefore, the ambient charred material that ends up in occupation debris is likely to include more accidentally charred food remains than if fire was not so important in processing. Indeed, a superficial impression of west Asian plant remains is that pulses are much more numerous and common in Neolithic assemblages than in later ones. Shifts in the ratio of pulses to cereals would reflect changes in agricultural practices. Over the course of the pre-pottery Neolithic at Cafer (de Moulins 1997), Gritille (Miller 2002) and Abu Hureyra (de Moulins 1997), the proportion of pulses goes down, as the tending of meat- and dung-producing animals increases (Fig. 2). Thus, changes in the pulse to cereal ratio parallel the contemporaneous process of animal domestication.

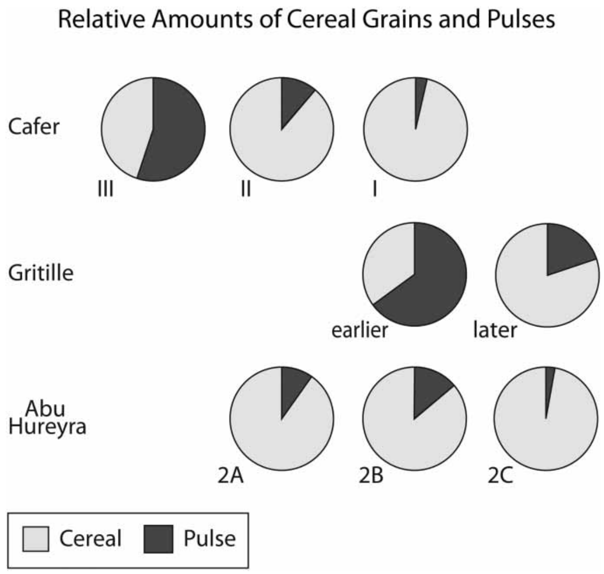

Figure 2 Relative amounts of cereal grains and pulses at Pre-Pottery Neolithic B (PPNB) sites along the Euphrates. Based on total amounts recovered. Data in Table 1.

Agropastoral continuum along the Euphrates

Because PPNB crops were processed in roasting pits, the assemblages from occupational debris assemblages probably include a higher proportion of accidentally charred food remains than in later periods. By the fourth millennium BC, plant and animal husbandry was fully integrated into the economies of west and central Asia, and the assemblages reflect that new development. In particular, plant remains provide a window onto the agropastoral continuum at the sites of Kurban Höyük, Hacınebi and Tell es-Sweyhat (Miller 1997a). The term 'agropastoral continuum' expresses the idea that people allocate their time and land for farming and herding as appropriate to their social and natural environment. Climate is a major factor in the decision-making process.

Clinal variation in vegetation along the Euphrates results from the north-to-south decline in precipitation. Under Holocene conditions, the area near Kurban Höyük would have been open woodland, as evidenced by a few large relict oaks that grow on a nearby ridge (see also pollen evidence-based vegetation reconstruction of van Zeist and Bottema 1991, fig. 45). South towards Sweyhat, the natural vegetation becomes increasingly steppe-like (Zohary 1973, map 7).

Land use, too, follows moisture availability. Where rainfall agriculture is more secure, towards the northern end of the study area, arable can be devoted to cultivation of food and fodder crops, and pasture comprises a smaller proportion of land devoted to subsistence pursuits. As you go south, dry-farming is less secure. Sheep and goats need less surface water than do cattle and pig, and so can be sent to graze further from the river. Arable land becomes more valuable for food crops, because herds of sheep and goats can be supported by the extensive steppe or open

Table 2 Data from Chalcolithic and Bronze Age sites along the Euphrates

	No. samples	Wheat (g, sum)	Barley (g, sum)	Seed: Charcoal (by weight, median)	Wild: Cereal (count: weight, median)
Kurban Höyük VI, Late 4th millennium BC	31	1·33	1·71	0·52	61
Kurban Höyük V, Early 3rd millennium BC	40	4·98	4·15	0·59	81
Kurban Höyük IV, Mid-3rd millennium BC	93	2·04	4·27	1·18	100
Kurban Höyük III, Late 3rd/Mid-2nd millennium BC	9	0·04	0·14	1·00	52
Hacınebi, Late 4th millennium BC	35	1·66	6·25	0·23	203
Sweyhat, Late 3rd/Mid-2nd millennium BC	17	0·20	4·65	0·35	950

Median values differ from Miller and Marston (2012) because additional samples were used. Kurban Höyük (unpublished laboratory notes; samples with no cereals are omitted from this table), Hacınebi (Stein *et al.* 1996a, b), Sweyhat (Miller 1997b).

woodlands. The ability to adjust subsistence pursuits according to environmental conditions permits substantial flexibility over space, and also from year to year.

The wild:cereal ratio gives some insight into the agropastoral continuum in these fourth–second millennium BC sites (Table 2). With the introduction of ceramics, roasting pits had fallen out of use because pulses and cereals are easily cooked with liquid in ceramic pots. Consequently, plant foods were less likely to become charred during cooking. Instead, charred plant residues in occupation debris are likely to be largely from fuel use, so many of the charred seeds from these later sites originated in dung burned as fuel (see Miller 1984; for alternative view, see Hillman 1984). The wild:cereal ratio would then be a proxy for steppe grazing vs. stubble grazing or foddering with crops (Anderson and Ertuğ-Yaras 1998; Miller and Marston 2012). To calculate the ratio, I divide the number of wild seeds by the weight of cereals for each sample. It is important to control for time period, since vegetation may be subjected to regional economic or climate variables. As might be expected, the wild:cereal ratio as an indicator of steppe-grazing is higher on the more southerly sites than at Kurban Höyük. Sites along the Euphrates dating to the late fourth/early third millennium show the expected trend in animal remains, too: there is a north-south cline in percent sheep–goat relative to cattle and pig (Table 3).

The spatial patterning is relatively easily explained by the precipitation cline. Remains from the multiperiod site of Kurban Höyük show that climate is not the only factor, however. The proportion of wheat relative to barley rises and falls with the percentage of sheep and goat relative to cattle and pig (Fig. 3). The median wild:cereal ratios does not track quite as neatly with the bone assemblage, but both are highest in the late fourth and early third millennia levels and lowest at the beginning and the end of the sequence (Fig. 3). Even though the correspondence between these data is not exact, the evidence for the plant and animal economies does seem to be related and can be explained as follows. In west Asia, wheat is grown for human food. Barley is primarily grown for fodder, though it may be eaten or brewed for beer. Where animals are sent to pasture and drought is a constant risk, farmers will spend less time and use less land growing fodder. So the signature for the pastoral end of the continuum is higher wild:cereal ratios, high sheep–goat relative to cattle and pig, and higher wheat percent. The agricultural end of the

Table 3 Comparison of number of bones of sheep and goat vs. cattle and pig from sites along the Euphrates, listed from north to south

	Caprine, cattle, pig (NISP, no. of identified bones)	Percent of sheep and goat	Sheep and goat/ cattle and pig
Karatut Mevkii, Late 4th millennium BC (estimate)	no data	10	0·11
Kurban Höyük VI, Late 4th millennium BC	75	28	0·39
Kurban Höyük V, Early 3rd millennium BC	118	82	4·56
Kurban Höyük IV, Mid-3rd millennium BC	768	74	2·85
Kurban Höyük III, Late 3rd/Mid-2nd millennium BC	149	26	0·35
Hacınebi, Late 4th millennium BC	424	58	1·39
Hajji Ibrahim, Late 4th millennium BC	167	57	1·35

Kurban Höyük: Wattenmaker and Stein (1986); Hacınebi: Stein *et al.* (1996b): table 13; Karatut Mevkii estimate based on graph in Stein *et al.* (1996b: fig. 34); Hajji Ibrahim (0·5 km from Sweyhat): Weber (2006, 196).

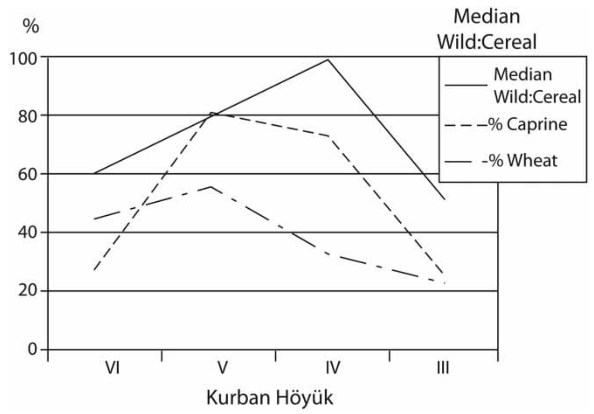

Figure 3 Comparison of median wild:cereal ratio, percent sheep and goat bone count relative to cattle and pig, and percent wheat relative to barley (by weight) at Kurban Höyük. Data in Tables 2 and 3.

continuum is suggested by lower sheep–goat relative to cattle and pig, lower wild:cereal ratios, and lower wheat percent (Miller 1997b; for an example from Gordion, Turkey, see also Miller *et al.* 2009).

These data also speak to the 2200 BC climate event, though inconclusively (see also Charles and Bogaard 2001). If dry conditions were pervasive and extensive enough to end Akkadian civilisation, as suggested by Dalfes *et al.* (1997), one might expect to see changes in agricultural practice and crop choice at that time. A shift to the more drought-resistant pastoral system at Kurban Höyük, however, seems to have happened early in the early third millennium (phase V), not towards the end. These data are consistent with the general consensus that the 2200 BC climate event did not have uniform and unambiguous effects over all west Asia (Marro and Kuzucuoğlu 2007).

Pastoral Nomadism in the Zagros

The last example uses excavated plant remains to trace landscape modification, even in the absence of settlement evidence. Archaeologically, sites occupied by nomads are notoriously difficult to recognise, yet we know that at some point in prehistory pastoral nomadism developed in the southern Zagros mountains. The historically known agropastoral system in the Kur River Basin – the plain of Persepolis – integrates settlement-based agricultural pursuits with the seasonal passage of Qashqa'i pastoral nomads. In the 20th century, the primary crops were winter wheat and barley. Sugar beet, sesame, bitter vetch and garden crops were also grown by villagers. There was some mechanisation, but as late as 1975, some people ploughed with mules and oxen. Families kept sheep, goat and cattle, too. At this elevation, ca. 1500 m, the farmers had to grow fodder for the animals because snow covers the ground in the winter. The need to grow fodder, therefore, was a limiting factor for the size of the farmers' herds, so there was ample pasture for the flocks of the Qashqa'i nomads who passed through the Kur River Basin en route to their summer pastures.

During the late fourth to early third millennia BC, the largest settlement in the Kur River Basin was Tal-e Malyan (Sumner 1990). The site is located at the border between the oak and the pistachio-almond woodlands (Fig. 4; Zohary 1973, map 7). Open oak woodland at the northwest end of the valley yields to wild pistachio and bitter wild almond on the lower slopes. At the southeast end of the valley, pistachio and almond trees dominate the vegetation. In between the land is cultivated, and there are also low-lying moist areas and riparian vegetation along the rivers.

Between about 3400 and 2600 BC, Malyan was a small urban agglomeration, ca. 45 ha, housing more than half the population in the valley. Clay tablets written in Proto-Elamite were found, and the pottery phase name is Banesh. The work of William Sumner and many others supports the view that full-time pastoral nomads were part of the sociocultural landscape by this time (de Miroschedji 2003, 24). The site was

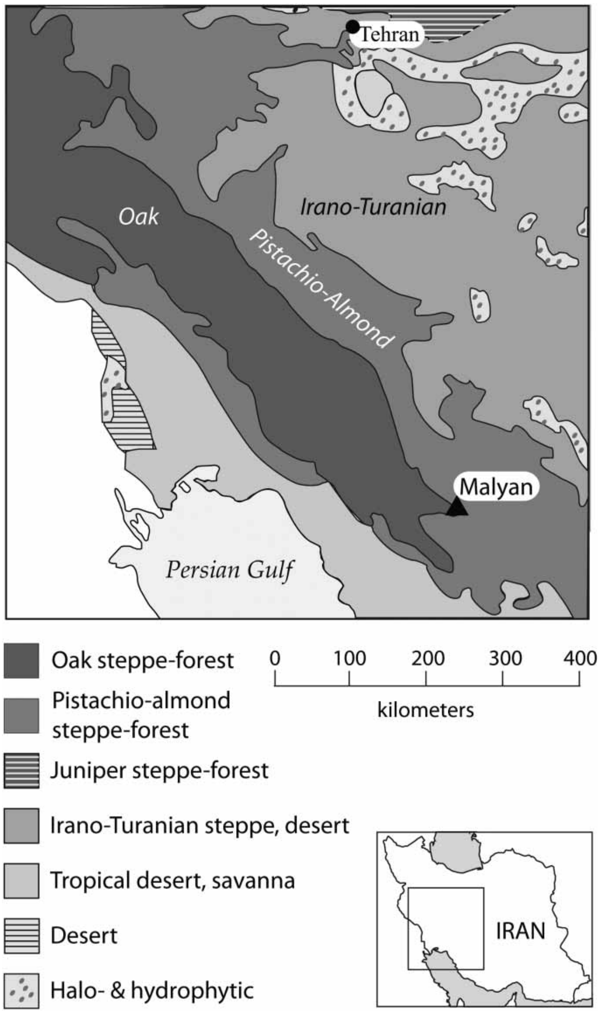

Figure 4 Inferred vegetation of western Iran. (Source: Zohary 1973).

almost completely abandoned in the mid-third millennium. Surveys in Kur River Basin and valleys to the northwest show that the near-abandonment of Malyan as a major settlement coincides with the virtual disappearance of any settlement at all in that 400-year gap over much of southern Iran. Malyan was reoccupied during the Elamite period (local phase: Kaftari, ca. 2200–1600 BC) (Sumner 1989, 2003, 54–55; Miller and Sumner 2004), growing to about 130 ha (and housing just under half the valley population) (Sumner 1990). Settlement also expanded to the southeast end of the valley and the settlement pattern became more complex.

The question is: how might plant remains give any further insight into this sequence of events? For example, during times of high population density, woody vegetation would be stressed. Year-round residents might need to clear land to farm, and settlers and nomads both need a daily fuel supply for cooking, and sometimes for heating and craft production. Therefore, intensity of wood use as well as fuel choices will be reflected in the archaeobotanical assemblage. Given a choice, wood is usually preferred over dung for fuel. With seeds coming from dung, the seed:charcoal ratio reflects dung vs. wood fuel, and so serves as a proxy for the intensity of forest use. At Malyan, the median seed:charcoal ratio is always fairly low: negligible in the Banesh period (0·0001) and rising to 0·04–0·05 during the more urbanised Kaftari period. This suggests that there was some increase in dung over wood fuel use, even in this wooded region. As a comparison, the median seed: charcoal ratios for the roughly contemporary sites along the Euphrates, Sweyhat, Hacınebi and Kurban Höyük range from 0·21 to 0·91 (Miller and Marston 2012).

For the preliminary wood charcoal analysis, the samples were assigned broadly to the Banesh or Kaftari period (Miller 1985). In 2003, William Sumner provided me with more refined chronological information. I was able to break the assemblage down into earlier and later phases for both periods (Table 4), which warranted a reconsideration of the original conclusions; in this contribution I include only charcoal weight, as the earlier study demonstrated that weights and counts in this particular assemblage were correlated.

Table 4 Wood charcoal from Malyan

	Middle Banesh	Late Banesh	Earlier Kaftari	Later Kaftari
N (total no. of samples)	47	15	69	11
N (pieces identified)	576	161	822	111
Total weight (g)	415·04	75·19	387·38	41·97
Weight examined*	287·82	40·02	285·43	26·77
Juniperus (%, wt)	38	31	10	0
Quercus (%, wt)	9	9	21	12
Prunus (%, wt)	1	3	15	4
Pistacia (%, wt)	11	1	23	10
Acer (%, wt)	1	24	16	40
Populus (%, wt)	34	5	1	2
Ulmaceae (%, wt)	2	27	3	8
Other**	4	1	11	25
Juniperus (% ubiq.)	64	47	7	9
Quercus (% ubiq.)	13	47	64	64
Prunus (% ubiq.)	40	40	64	18
Pistacia (% ubiq.)	40	7	57	45

*Taxon percent by weight <100% because 'total weight' includes minor components and unidentified.
**Other minor components not included in Fig. 5: mostly *Vitis*; small amounts of *Fraxinus*, *Daphne*, *Vitex*, cf. *Capparis* and unidentified.

The main forest trees in the assemblage are juniper, pistachio, almond and oak (Fig. 5). Today, very little juniper (cf. *Juniperus excelsa* M. Bieb.) grows in the Kur River Basin woodland. Juniper is not a food source for people, it grows very slowly, and does not grow back from a stump the way oak does. So juniper is likely to be replaced by faster growing trees once it is cut down. There are several species of wild pistachio and wild almond in this part of Iran (*Pistacia eurycarpa* Yaltirik, *P. khinjuk* Stocks and *Prunus scoparia* Schneider, *P. kotschyi* (Boiss. & Hohen.) Meikle). Based on the modern distributions, the Kur River Basin is at the upper edge of their primary distribution. Wild pistachio produces a very small nut that is mostly eaten as a condiment. The wild almond produces an intensely flavored nut that has a strong bitter aftertaste, but people do collect it and eat it. Both are cut for fuel (and can regenerate if not over-harvested), the nuts are collected (e.g. Salehi *et al*. 2010, 188), and the leaves are eaten by animals. Oak (*Quercus aegilops* subsp. *persica* (Jaub. & Spach) Zohary) is fairly resistant to grazing, and acorns may be collected as winter fodder or ground into flour for bread (see Salehi *et al*. 2010, 188). The wood makes an excellent fuel. Based on the modern distribution, the closest source of oak was probably the valley edge, about 10-km distant.

Other charcoal types include maple, poplar/willow, hackberry and ash. Today, maple (*Acer monspessulanum* L.) grows in varied settings: in relatively moist areas, but also as a minor component of both the pistachio-almond forest and the oak forest. The other important taxa are poplar (*Populus nigra* L., *P. alba* L.), willow (*Salix excelsa* S.G. Gmel.) and hackberry (*Celtis australis* L.), which grow in moister areas. In the laboratory, I did not distinguish elm charcoal from hackberry, so that type is listed as Ulmaceae in Table 4 and Fig. 5.

Although the Malyan charcoal is not a direct reflection of the woodland composition, it did originate in domestic disposal contexts and is therefore likely to reflect the relative amounts of available wood (see,

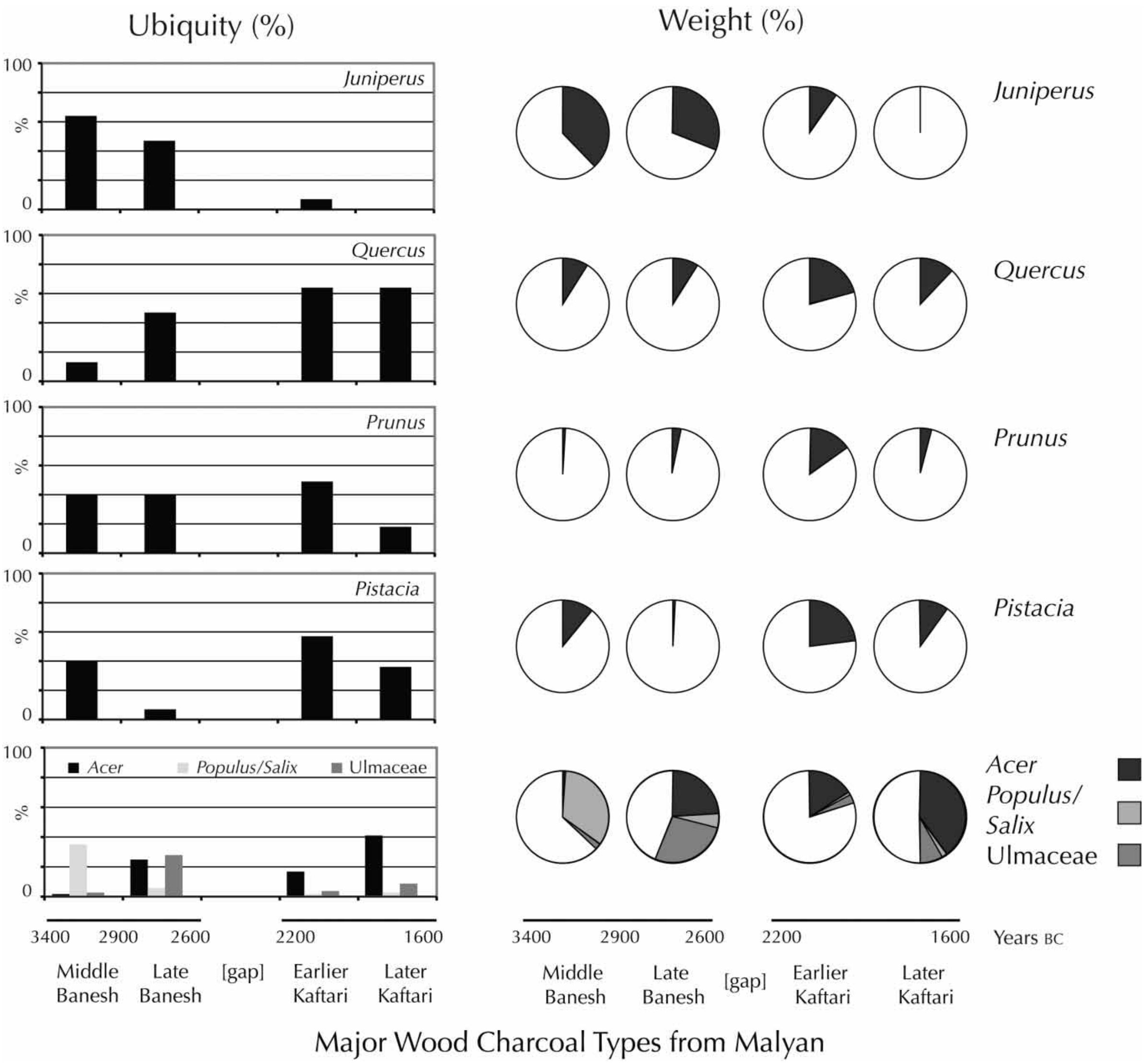

Figure 5 Major wood charcoal types from Malyan. Data in Table 4.

for example, the criteria presented by Théry-Parisot *et al.* 2010, 143 for paleoecological reconstruction). In general, the main forest woods decline and are replaced by faster growing types during the Banesh and Kaftari periods, yet they seem to regenerate during the occupation gap. A more nuanced picture of forest exploitation emerges if one looks at the shifts in proportions of the individual taxa.

Initially a substantial part of the charcoal assemblage, juniper would have been an important component of the forest in the Banesh period and it probably grew fairly close to the site. Its steady decline suggests that is exactly what happened, as it would not have been competitive with faster-growing species. Based on the modern distribution of pistachio and almond, it is likely that both were among the most common trees growing on the well-drained parts of the valley closest to the settlements. They would have been cut for fuel and field clearance (Miller 1990). Pistachio declines initially, and seems to recover during the settlement gap, only to decline again during the more populous Kaftari period. Both almond and pistachio seem to have done well during the settlement gap. The presence of oak in the assemblage holds steady during the Banesh period, which suggests oak woodland did not have to be cut down to create fields, perhaps because it grows further from the site, on the slopes at the edge of the plain.

This analysis is based on a fairly small number of samples and amount of wood charcoal. With percent data, if some variables go up, others have to come down, to add up to 100%. Ubiquity, the percent of samples containing a particular type, helps assess the validity of percent data, because the measures for each taxon are independent. Whether measured by percent amount or ubiquity, the trends for each of the four main forest woods are similar, which provides a little more confidence in the stability of the pattern (Fig. 5). By both measures, juniper declines steadily. Pistachio declines, but recovers during the settlement gap. The correspondence between the ubiquity and percent measures for oak and for almond is not quite as close. The bottom row illustrates the woods that are riparian or minor components of the oak forest and the pistachio-almond forest (maple, poplar, hackberry) (Fig. 5). As a group, they do well during the periods of high-settled population, when the primary forest is stressed. To summarise, the wood charcoal distribution suggests that as land was cleared for fields and trees were cut for fuel during the two periods of urbanised settlement, the primary forest woods were not as competitive, and so declined. During the settlement gap, those primary forest trees recovered, except juniper.

These same data illustrate how it is possible to infer the archaeologically invisible presence of nomads and their flocks: *something* happened to the forest composition during the settlement gap. The charcoal of nut-producing trees rises even as that of both slow-growing juniper and faster-growing trees declines. If this reflects an actual increase in nut-bearing trees and decline in the other types, it suggests that pastoralists were actively managing their woodland by protecting plant food sources over trees that do not produce edible fruits. In this way they left a permanent mark on the landscape.

Conclusion

As archaeologists, we have to separate the study of plant and animal remains for some obvious reasons: taphonomy, recovery methods, laboratory analysis methods (quantification), the nature of the organisms themselves (i.e. there are more plant types than animal types, but more identifiable animal parts than plant parts. Yet the ancient people we study lived in an environment shared with all kinds of plants and animals. Understanding how plants, animals and people coexisted on the landscape is not straightforward, but there are a variety of ways we can look at our data to come up with a unified picture, some of which I presented here. Our datasets are as interdependent as the ancient subsistence systems we study.

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