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Interpreting Ancient Environment and Patterns of Land Use: Seeds, Charcoal and Archaeological Context

Geçmiş Dönemlerin Doğal Çevre Ortamı ve Arazi Kullanım Düzenlerinin Yorumlaması: Arkeolojik İçerik açısından Tohumlar ve Kömür

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Gordion'daki yerleşim dolgusundan ve yanmış binalardan elde edilen geçmiş zamana ait bitki kalıntıları, Son Tunç Çağ'ından nispeten yakın zamanlara kadar bölgenin orman örtüsünde ardıç, meşe ve çam ağaçlarının hakim olduğunu göstermiştir. Böyle olmasına rağmen, ormanlık alan azaldıkça ormanın bileşimi de değişmiştir. Bu dönemin başlarında yakacak olarak beliren ardıç ağacı, sonlarına doğru büyük ölçüde yok olur. Sadece önemli bir yapı malzemesi olarak kullanımı sürer. Meşe ağacının yakacak olarak kullanması ise ters bir örnekleme gösterir ve zaman içinde önemi artar fakat bu bölgede yapı işlerinde hiçbir zaman kullanılmamıştır.

Plant macroremains represent only a small portion of the plant materials that were ever brought onto an ancient settlement, yet they can tell us more about plant use and the environmental setting of ancient settlements than virtually any other category of archaeological material. Since the remains come from plants that were used in a cultural context, it is useful to think of them as a special class of artifact rather than as some naturally occurring phenomenon. Archaeological provenience and the condition of the plant material itself provide clues to the ancient cultural context. This information is then used in evaluating the remains. For example, was a piece of charcoal found inside a hearth or as part of a fallen roof beam? Was a grain of barley found charred in a trash deposit with a wide variety of other seeds or as one of many grains in a burnt storeroom, or as a mineralized grain in a latrine deposit?

To understand an archaeobotanical assemblage, it is therefore important to consider the nature of preservation: are the remains charred, mineralized, dry, or waterlogged? Ordinarily on Near Eastern archaeological sites, most plant macroremains are preserved by having been charred in antiquity. Some plant materials, like those used for fuel, are very likely to come into contact with fire. Less commonly, vegetal remains may be accidentally preserved—from construction and furnishings, stored food, or artifacts. Thus, an important question is, what cultural or natural processes could have preserved the material?

If botanical remains are charred, it can be very informative to integrate the analyses of the seeds and charcoal, because items may have been burned together for the same purpose, namely fuel. A mixed fuel deposit may contain wood, dung, and seeds from dung or plant stalks used as fuel. Interpretations based on one type of material can be checked against results based on the others.

Current research at the ancient city of Gordion, in central Anatolia illustrates these points.[2] Gordion was the capital of the Phrygian state, and it is one of few excavated urban sites in central Turkey that date to the late second and early first millennia B.C. with no major gaps in occupation (Table 2). It is known as the place where Alexander cut the Gordian Knot; Herodotus mentions it as the home of King Midas. We know very little about how the city was supplied with food and fuel, so charrred plant remains.

were collected as evidence of ancient environment, land use, and pyrotechnology. The interpretations presented here are not final, because they are based on work in progress. This means that the results of future research and excavation can be used to verify and refine patterns that have emerged so far, as well as test the strength of the interpretations of ancient environment and land use.

Environmental setting

Centuries of human influence on the landscape make it hard to imagine the "natural" vegetation in central Anatolia. Available moisture is the main limiting factor for tree growth, and precipitation follows altitude. At elevations below about 700 m steppe vegetation prevails. Above 700 m, scattered trees can grow in a steppe-forest formation, which, at higher elevations, can be fairly dense.[3] Gordion itself is at the upper limit of the steppe, but a much wider area around the site is virtually treeless today, except along rivers and in watered gardens. A little higher up, starting at about 10 km from the site, there is some scrub juniper (Juniperus) and oak (Quercus), and at Mihaliççik, about 40 km away, at an elevation of about 1000 m, there is a pine (Pinus) forest with an understory of oak and juniper (Table 1). Of the three dominant types, pine is the only one that grows a fairly tall and straight trunk (up to 30 m in some parts of Turkey). Oak and juniper (a particularly slow-growing tree) would not reach the height of pine, even under favorable moisture conditions.[4]

The modern vegetation zones do not correspond exactly to those of the past. For example, in the pine and oak woodlands of Turkey, "pine forests are easily transformed into oak forests" because "the pines do not recover from cutting but the oaks do regenerate."[5] In fact, fuel-cutting and grazing, rather than climate, account for the near total absence of juniper and oak steppe-forest above 700 m.

Scanty as the modern arboreal vegetation is, it provides a baseline against which one can test ideas about patterns of ancient plant and land use. The deep stratigraphic sequence at Gordion is particularly useful for the study of the long-term effects of the human presence in the region, though climate change cannot be completely ruled out as a factor in how people exploited the landscape.

Archaeological contexts of Gordion plant remains

Substantial archaeological work between 1950 and 1973 revealed a deeply stratified site that had deposits dating from the Early Bronze Age to the Medieval period.[6] The plant remains from these excavations are primarily charred seed concentrations and timbers from the Early Phrygian destruction level in the Gordion City Mound (ca. 700 B.C.), and from timbers and wooden tomb furniture found in Phrygian burial mounds in the area.

A stratigraphic sounding undertaken in 1988 and 1989 established a sequence of archaeological phases. The excavations greatly expanded the amount and variety of plant materials available for study.[7] The charcoal analyzed so far consists of pieces picked out by hand during excavation and the seeds were extracted by flotation of soil samples. The new materials come primarily from occupation debris including pits in residential areas (Late Bronze Age, Early Iron Age, Middle Phrygian, Medieval), pits containing refuse from domestic as well as manufacturing activities (Late Phrygian), occupation debris (Hellenistic), and occupation debris from an elite quarter (Early Phrygian). Building material (wood charcoal) from three burnt structures gives evidence of timber use in Early Iron Age, Early Phrygian and Hellenistic Gordion (Tables 3,4,5,6; fig. 1). Wood from the previously excavated Early Phrygian "Midas Tumulus" tomb and its furnishings adds to the range of excavated contexts.[8]

In summary, archaeobotanical remains come from three general context types: structures, furnishings, and occupation debris. The structures and furnishings provide material most like traditional archaeological artifact categories. In terms of bulk, most of the wood and charcoal samples come from burnt buildings on the City Mound and the log cabin-like structure at the bottom of the Midas Tumulus. The second category, tomb furnishings, represents small but high-status items made of wood. The most widely distributed material, however, consists of charcoal and seeds from settlement debris.[9]

Construction materials and furniture

As with other artifacts, construction timbers and furniture can be analyzed in terms of function, source material, distribution within the site, and ancient cultural significance. Characteristics like length and resistance to decay determine which woods are most suitable for building. As building timbers are fairly permanently installed and may be reused in new construction, it may be both necessary and worthwhile to bring them from afar. Indeed, historical records show that ancient peoples could and did transport large timbers over great distances, and reuse of old timbers has been documented at Gordion itself.[10] Woods which are rare or exotic may not have been equally available to all members of a society.

Functional considerations seem to play a major role in timber choice in the three burnt buildings at Gordion (Table 3). For example, the earliest burnt structure ("BRH") was a one-room mud, reed and pole structure, about 6.4 m wide, that dates to the Early Iron Age.[11] Postholes along its perimeter that supported reed bundles and postholes towards the middle of the structure that are filled with charcoal are generally 10-15 cm in diameter. Juniper predominates in the charcoal from the building, so it was probably the main structural wood. Juniper, which would have grown closer to Gordion than pine, seems well suited for this building method, since only short timbers were required. Furthermore, juniper is highly resistant to decay and fairly soft and easy to work.[12] The smaller quantities of pine, oak, poplar, and other wood types found in structure BRH could come from other structural material, furnishings, or fuel stored in the room.

The second example is a stone structure that dates to the Early Phrygian Destruction level. Terrace Building 2A is the anteroom of one of eight almost identical attached structures associated with the work area of the Early Phrygian palace complex.[13] Most of the charcoal comes from ceiling beams. Some of the timbers are 20 cm and more in diameter, and they spanned an open space of at least 12 m. Nearly all the wood is pine, a suitable choice in terms of length.

The third source of charred construction material is a room, about 7-7.5 m wide, in a structure with a stone foundation that dates to the Hellenistic period. There is a square stone and mud plaster feature in the center of the room that probably supported a column for the roof. The charcoal is primarily from collapsed building material in what appears to be an ordinary residence. As in the Early Phrygian building, pine is the principle wood used.

These three buildings span about 600 years of settlement at Gordion. They show that wood for residential buildings was selected from a narrow range of locally available types. In fact, only two of the three dominant woods of the steppe-forest were used in any quantity.

Some of the rare woods found in the Early Phrygian Midas Tumulus provide an interesting contrast with more ordinary construction materials.[14] Much of the wood of the tomb structure is pine, the same timber used in the slightly later palace complex work area. Juniper was also used, though by the Early Phrygian period it was probably already fairly rare. Lebanon cedar (Cedrus libani) formed part of the floor and wall of the burial chamber. The closest Lebanon cedar grows near Afyon, about 100 km from Gordion.[15] Boxwood (Buxus), which would have also have come from the Black Sea forests about 125 km north of Gordion,[16] is a component of some of the furnishings.[17]

The wood from the Midas Tumulus shows how plant materials help us refine our understanding of ancient social systems: what kind of society would produce a person wealthy and powerful enough to import exotic woods over long distances and to display them briefly before covering them with a 53 m high pile of earth? It is no accident that cedar and boxwood have been found only in the burial mound of a very high status individual who lived during the florescence of Phrygian civilization. Clearly, the distribution of wood remains may reflect the social conditions of an ancient society as effectively as more traditional "status objects" found in archaeological sites.

Charcoal in settlement debris as an indicator of arboreal vegetation

The primary source of charcoal in settlement debris is the residue of incompletely burned fuel. An assemblage of fuel remains reflects the state of the local woodland contemporary with a given deposit better than either the large and reusable construction timbers or the rare and possibly exotic products of the woodworker's art. Because people need a constant supply of fuel, and wood is bulky, cost of transport is an important factor determining fuel choice: wood closer to home will probably be cut first. A simple model that can begin to explain the assemblage of charcoal from settlement debris posits that people gathered wood fuel as close to the site as possible, and their choice of species reflects the vegetation from which the wood was gathered. If it has not been completely disturbed, the modern vegetation can suggest which types one would expect to see in the archaeological material. If one's expectations are not met, new avenues of investigation may open up.

Two trends are apparent: juniper declines and oak increases (fig. 1). The pattern of oak and juniper exploitation is consistent with the two most plausible interpretations of the composition of the steppe-forest as reconstructed from remnant vegetation. The first presumes there was a zone with juniper closest to the site, with oak and juniper mixed at higher elevations. The second presumes oak and juniper together grew closest to the site, but oak was not favored because its wood is very hard or because it was spared for other uses (acorns as fodder, oak bark for tanning). Either way, juniper might be the first fuel wood to be used up.

A comparison of the fuel charcoals with contemporary construction material sheds further light on vegetation and wood use.

First, the dominant wood types in the Early Iron Age and Early Phrygian structures reflect the dominant fuel charcoals in contemporary occupation debris, juniper and pine respectively. The situation in the Hellenistic building is different. Though pine continues to be the major structural material, the primary fuel is oak. This discrepancy between preferred fuel and construction material suggests that pine was no longer so available as a fuel, but it was still worth transporting for building. In addition, the shorter beams spanning the burned Hellenistic structure would not have required trees as old and large as those supporting the roof of the earlier building. The local oaks, though hard and difficult to work, were nonetheless considered adequate for fuel.

Depletion of wood sources around the site can also be monitored by considering the trees that are characteristic of secondary growth and riverine associations: hawthorn (Crataegus) in the steppe-forest and willow (Salix), poplar (Populus) and tamarisk (Tamarisk) along rivers. These types are not common in the archaeobotanical assemblage. Before the Middle Phrygian period they never exceed 15% of the assemblage. They occur in somewhat higher proportions in the later deposits, a possible indication that tree felling began to have a small, but noticeable effect upon the vegetation as reflected in the archaeobotanical record.

In contrast, pine does not follow a clear pattern of increase or decrease. Under current conditions, pine grows fairly far from Gordion, yet it seems to have been more important than oak until Middle Phrygian times. If the vegetation zones of today are the same as in the past, and if distance determines transport cost and fuel choice, then it is hard to explain the relatively high proportions of pine in the first half of the archaeological sequence. One possibility is that pine grew at lower elevations closer to Gordion than today. Oak tends to replace pine in the pine-oak associations of Anatolia.[18] Climate may also be relevant in the first half of the archaeological sequence. The pollen record of central Anatolia suggests that moisture levels at about 1500 B.C. were higher than today,[19] which might have allowed pine to extend down the slopes, mixed with oak and even juniper. From initially high levels relative to oak, pine may have declined through a combination of fuel cutting and desiccation.

The pine peak in the fuel charcoal of the Early Phrygian period, if not simply a result of small sample size, may require a different explanation. By Early Phrygian times, juniper use had declined precipitously, probably because centuries of fuel cutting had depleted this slow-growing tree. The oak component of the oak-juniper steppe-forest of lower slopes replaced juniper, and the radius of fuel procurement expanded into the oak and pine zone. According to William Sumner's regional site survey, the Phrygian period marks the peak of population in the Sakarya river valley,[20] so stress on sources of wood for both fuel and construction would have been great. We know from the burial mounds in the region that the rulers of the Phrygian state were powerful enough not only to command labor for raising monumental burial mounds, but also to have access to the trade in imported woods that were unobtainable by more ordinary folk, like cedar and boxwood. So one can at least raise the possibility that a population large enough and organized enough to support a good amount of non-productive activity might also have supported specialized charcoal cutters working in the pine forest, provisioning the palace, if not the entire city, with charcoal. Even though oak makes a fine charcoal, charcoal production on the lower, drier slopes would have been less economical because the trees were spaced further apart.

Seeds and Charcoal

Land use involves more than just tree-felling, and much can be learned by including seed analysis in an archaeobotanical study. Seeds from archaeological sites have proven their value in the reconstruction of many aspects of ancient agricultural economies. Crop and other food remains were a major focus of study even before flotation revolutionized the study of archaeobotanical remains, and there is still a tremendous amount to be learned. Indeed, the Gordion seed remains from the 1988/1989 excavations include about fifteen virtually pure seed samples from the floors of burnt buildings, and the 1950-1973 excavations turned up even more. A less common approach to archaeological seed assemblages is one which tries to account for the archaeological context of all the seed remains, not just the crops and food.

Only rarely are archaeological deposits simply the remains of cultural materials abandoned in the midst of some activity. Rather, they represent the accumulation of debris from a variety of ancient activities, ancient trash disposal, and post-depositional processes, so the context of use can only be inferred indirectly. For example, a broken pottery vessel in a trash pit is trash, even if it had previously served as a container. If one thinks about how people use plants, and if the plant remains available for study are those that were charred in the past, it becomes clear that the charring itself suggests a possible context of use for wood and seed remains, namely fuel.

In the Near East, traditional fuels are wood and wood charcoal, brush, and dung. The first two are generally preferred. Remnants of both burned brush and dung have been found on some archaeological sites. For example, a shrub charcoal (Chenopodiaceae) was the most common wood type at Tell es-Sweyhat, on the Syrian steppe.[21] Charred animal dung has been found at Ali Kosh,[22] Can Hasan,[23] and many other sites, though not everyone agrees that the dung had been burned as fuel. Brush and dung sometimes contain seeds that persist in the archaeobotanical record,[24] so charred seeds obtained by flotation can provide another line of evidence for assessing the impact of fuel exploitation on the environment.

The argument that charred seeds might have originated in dung fuel was first developed in the analysis of the archaeobotanical assemblage at Malyan, a third millennium B.C. city in southern Iran.[25] There, a shift in the proportions of different charcoal types, most notably a decline in juniper and an increase in oak, suggested an increasing radius of fuel procurement between the beginning and end of the third millennium B.C.; oak grew further from the site than many of the other identified types. A ten-fold increase in the proportion of seed remains (by weight) relative to charcoal weight (and a four-fold increase in the number of seeds of wild plants relative to charcoal weight) was attributed to dung, an alternative fuel that became economical as trees close to the site were cut down.

The juniper decline and oak increase at Gordion would seem parallel to the situation just described. As the Sakarya basin is fairly dry, with an annual precipitation of about 350 mm,[26] it might not take much to put stress on wood resources around Gordion by fuel-cutting, grazing, and other activities. If wood were to become scarce, one might expect alternative fuels like dung and brush to become more popular.

To compare materials most likely to share context of use, flotation samples from the burnt buildings were not included in the analysis because charred construction debris dominated those samples. The remaining samples contain charred material which probably was burned intentionally. This analysis therefore presumes that most of the seeds in the flotation samples originated in non-tree fuel sources. As a rough measure of patterns of fuel use, therefore, three related but slightly different indicators of the importance of these presumed non-tree fuel sources were calculated:

1) Seed: charcoal ratio (fig. 2). Cultigens, primarily wheat and barley, account for the bulk of seed weight in the flotation samples. As at Malyan, these seeds might represent the remains of animal fodder incorporated into dung, so the seed:charcoal ratio lets one approximate the relative importance of dung and wood as fuel. Since the cultigens are usually fairly large and recognizable in fragmentary form, I use the weight (in grams) of the seeds and charcoal fragments larger than 2 mm.

2) Wild seed: charcoal (fig. 3). Wild plants not collected for human food account for most of the seeds, and the number of wild seeds relative to charcoal would be another comparison between dung and wood as fuel. Weed seed count is most appropriate for the numerator, because most weed seeds are very small and are not identifiable in fragmentary form.

3) Frequency of anti-pastoral types (fig. 4). Plants that are avoided by animals (in this case, wild rue [Peganum harmala] and camel thorn [Alhagi camelorum]) are less likely to have originated in dung fuel. According to a Yassihöyük farmer,[27] herbivores will eat them in dried form, but the camel thorn and wild rue seeds could be the remains of brush fuel. Since these two types are not very numerous, the most appropriate measure of their abundance is based on frequency (the percentage of samples in each period containing a given type).

The values of these measures are highly correlated, though changes through time do not follow a simple progression. Cultigens, wild plants in general, and anti-pastoral species occur early and late in the stratigraphic sequence, with a low point in the Early Phrygian deposits. As indicated above, the underlying factor influencing this distribution could be patterns of fuel consumption—the burning of dung and brush relative to wood.

The Gordion seed analysis informs the interpretation of the charcoal assemblage by providing a way to assess the alternatives to wood fuel. If wood were to become scarce, one might expect alternative fuels like dung and brush to become more popular. The persistence in all periods of major components of the climax steppe-forest, namely pine and oak, and relatively low levels of secondary wood types even into the later periods suggested that wood continued to be available for fuel into Medieval times. If this interpretation is valid, one would expect measures of alternative fuels to remain relatively stable. On the other hand, if people had irrevocably depleted local wood sources, one would expect to see the indicators of alternative fuel use showing an increase. What we see is some charcoal evidence for stress on wood resources by the Late Phrygian: the decline in juniper, increase in the indicators of secondary and riverine trees, and the suggestion that pine beams were smaller in the Hellenistic building than in the Early Phrygian one. The fact that the seed indices are higher in the latter half of the archaeological sequence, but only slightly, supports this interpretation. Namely, trees, even if widely spaced, continued to be economically significant elements of the landscape, despite some reduction in tree cover over time. The virtual absence of trees that today characterizes the plains around Gordion postdates the Medieval period.

Social implications of access to wood resources

Fuel analysis can also refine aspects of the analysis of building materials. The assumptions underlying the fuel analysis are that (1) wood fuel is generally preferred over dung and brush, (2) transport cost would make pine a relatively expensive fuel at Gordion, and (3) pine would not become economical until wood sources closer to home were depleted. Therefore, if transport-based economic considerations prevail and pine is the most abundant wood in the samples, non-wood fuels like dung would become more common because they would be cheaper. So at Gordion, we might expect high pine levels to be associated with high alternative fuel indices.[28] If, on the other hand, high pine levels are associated with low alternative fuel indices, the assumptions about transport considerations do not hold, and other explanations can be sought.

In fact, the Early Phrygian fuel remains do not seem to reflect the expectations based on the simple transport cost model of fuel use-pine is common, but evidence for dung or brush fuel is slim. If this pattern is confirmed after more material is analyzed, cultural and climatic explanations for the anomalously high pine proportions could be tested. For example, the highest levels of pine occur in the pre-Destruction levels of the Early Phrygian period, from deposits associated with elite quarter residential architecture.[29] The high pine levels might therefore reflect those high status residents' access to high quality fuel. Or, if the Early Phrygian period was a time when wealth was broadly distributed in a politically centralized polity, a strong division of labor and market forces or state-organized labor may have made charcoal manufacture a viable occupation and the pine forest a viable fuel source.[30] Finally, given the present lack of evidence one way or another, climate amelioration cannot be ruled out entirely.

Conclusions

The Gordion charcoal anlysis suggests that juniper, oak and pine dominated the woody vegetation in the region from the Late Bronze age to relatively recent times. Even so, the composition of the woodland changed as the wooded area diminished. Juniper, which dominates as a fuel at the beginning of the sequence, largely disappears by the end. It lasts longer as an important construction material. Oak used as fuel shows the reverse pattern, rising in importance over time, but it was never used in this area for constuction.

The interpretations presented above are consistent with the available data, but the amount of material analyzed to date is not that great. It is not easy to know how much material one needs to analyze in order to reach firm conclusions. Much of archaeobotanical analysis depends on recognizing patterns in the distribution of plant remains and interpreting them.[31] Patterning based on a small collection of material will usually not be very stable. If analyzing one or a few more samples will drastically alter the trends one has observed, it is a good idea to keep working.[32] The analysis of the Gordion plant materials is not yet complete, and there is a good chance that some of the patterns I have identified will not hold up as more samples are analyzed. I have tried to demonstrate a worthwhile approach to the analysis of charred macroremains, one that uses archaeological context and charred seed and wood assemblages to reach a broader understanding of ancient society.

End Note on quantifying the charcoal

Many factors produce an archaeobotanical assemblage, even if cultural patterning narrowly determined how plants were used and disposed of in antiquity. The variety of plants used, what is preserved, the location of excavation squares and interpretation of the archaeological deposits from which flotation samples are taken are all variables that affect the composition of an archaeobotanical assemblage. It is important to look at enough material (in terms of number and size of samples) so that the unavoidable ambiguity of the archaeological interpretation will not mask whatever real patterning may have survived in the archaeological record.

The security of the charcoal interpretation rests on a number of assumptions. First, even if the functional assignment of any one sample to fuel or construction is wrong, errors will be insignificant if the number of samples analyzed is large enough. With regard to fuel residues, I presume that quantities of the various taxa reflect availability in the local vegetation, in general terms.

Charcoal quantities are based on the weight of charcoal greater than 2 mm, as well as the proportion (by weight) of the sample that was analyzed and the number

of pieces examined. Charcoal counts and weights tend to be correlated,[33] even though wood density varies between types. For example, oak is very dense, pine is not, and juniper is in between; analysis by weight would therefore tend to over-represent oak, and analysis by volume would over-represent pine. Volume is not a practical measure for these samples, many of which consist of one or two small pieces of charcoal.

Especially in Terrace Building 2A, it was not practical to collect every piece. Since structural elements are basically just very large, though broken, artifacts, it is not reasonable to compare them by either counts or weights. Therefore, I just use frequency in the analysis by YH phase (Table 3). Mass is more directly related to ancient fuel use than number of pieces, and is used in the analysis of the fuel remains (Table 6).

In calculating the summary chart of fuel (Table 6, Fig. 1), each sample was weighted by size (grams). That is, the summary chart presumes that the examined charcoal in any one sample is representative of the total in that sample. Since an attempt was made to collect all charcoal that was noticed during excavation, I have decided to treat the major time periods as the analytical units; that is, for each period I added the weighted totals of the samples together and divided by the total weight of charcoal retrieved to calculate the percent of different types by period.

The frequencies (Table 4) and amounts of charcoal in occupation debris (Table 6) show similar, though not identical trends. A comparison between the frequency (Table 3) and amount (Table 5) of charcoal from the burnt structures shows very little difference. Juniper, pine and oak are found in the Early Iron age structure, and pine predominates in the two later structures.

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1- A version of this paper was presented at the symposium, "Arqueologia medioambiental a traves de los macrorestos vegetales," November 7-8, 1991, madrid, and was distributed in a 1992 collection of symposium papers.
2- Major excavations at Gordion and nearby burial mounds were carried out by a University of Pennsylvania team under the direction of Rodney Young between 1950 and 1973, who reported results in various places (see K. Devries, 1980, R.S. Young, 1975). Since 1988, the Godion Project has been directed by G.K. Sams; excavation sponsored by the University of Pennsylvania under the direction of Mary M. Voight have provided most of the plant remains discussed in this paper (G. K. Sams, M.M. Voight, 1989;1990).
3- M. Zohary, 1973
4- P. Davies, 1965-1982
5- S. Bottema, h. Woldring, 1984, 139
6- R.S. Young, 1975
7- M.M. Voight, 1994; 1996
8- H. Kayacık, B. Aytuğ, 1968; B. Aytuğ, 1998
9- See and note concerning measures of assessing charcoal quantities.
10-P.I. Kuniholm, 1977,48
11- M.M. Voight, 1994,269
12- See A. J. Panshin, C. de Zeeuw,1970
13- R.S. Young, 1976, M.M. Voight, 1994,272-273
14- H. Kayacık, B. Aytuğ, 1968
15- P. Davis, 1965
16- P. Davis, 1982
17- B. Aytuğ, 1998
18- S. Bottema, h. Woldring, 1984
19- S. Bottema, h. Woldring, 1990
20- G.K. Sams, M.M. Voight, 1990
21- C.M. Hide, 1990
22- H. Helbaek, 1969
23- D.H. French, 1972
24- See N.F. Miller, T.L. Smart, 1984
25- N.F. Miller, 1982
26- This figure refers to annual Presipitation at Polatlı reported in the Meteoroloji Bülteni, 1974,356
27- E. Bekler, personal communication
28- I mesure pine by its proportion (by weight) relative to other charcoal types, and alternative non-wood fuels by the various seed indices (seed: chacoal, weed seed: chacoal, and ubiqity of anti-pastoral types).
29- M.M. Voight, 1984,278
30- See, for exampel, S.D. Olson, 1991
31- V.S. Poper, 1998 an T.L. smart, E.S. Hoffman, 1988 provide good general discussion of many of these issues
32- See, for example, discussion by F.J. Green, 1979 and U. Willerding, 1991
33- N.F. Miller,1985

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Latin	**Turkish**	**English**
Alhagi	deve dikeni	camelthorn
Buxus	şimşir	boxwood
Cedrus libani	Toros sediri	Lebanon ceder
Chenopodiaceae	ispanakgiller	goosefoot family
Crataegus	alıç	hawthorn
Juniperus	ardıç	juniper
Pinus	çam	pine
Quercus	meşe	oak
Peganum harmala	üzerlik	wild rue
Populus	kavak	poplar
Salix	söğüt	willow
Tamarix	ılgın	tamarisk

Table 1: Plants mentioned in text

	YHSS	Approximate Cultural Period
AD 1000		
	1	Medieval
AD 500		
	2	Roman?
AD/BC		
	3	Hellenistic
	4	Late Phrygian
500 BC	5	Middle Phrygian
	6	Early Phrygian
1000 BC	7	Early Iron Age
	8, 9	Late Bronze Age
1500 BC	10	Middle Bronze Age

* The modern name of Gordion is Yassıhöyük, abbreviated YH; "YHSS" refers to the Gordion stratigraphic sequence.

Table 2: Gordion Stratigraphic Sequence*

	BRH Structure	**Terrace Bldg 2A**	**"Abandoned Village"**
YH Phase	7	6	3
# samples	21	28	21
# pcs exam'd (total)	169	140	202
Oak	14	7	52
Pine	48	96	95
Juniper	76	0	0
Conifer	5	0	0

Table 3: Frequency of charcoal from Gordion burnt structures (% of samples containing a particular type)

	Late Bronze	Early Iron	Early	Phrygian Mid	Late	Helle-nistic	Medi-eval
YH Phase	8/9	7	6	5	4	3	1
# samples	9	38	18	8	78	33	13
# pcs exam'd	50	162	110	52	528	232	69
Oak	11	36	28	87	64	76	46
Pine	33	53	94	37	63	55	85
Juniper	89	32	39	12	36	15	8
Conifer	0	11	11	0	10	3	

Table 4: Frequency of fuel remains from Gordion samples (% of samples containing a particular type)

	Early Iron BRH Structure	Early Phrygian Terrace Building 2A	Hellenistic "Abandoned Village"
YH Phase	7	6	3
Tot. wt.(g)	374	6206	798
Oak	5	1	11
Pine	20	99	89
Juniper	64	0	0
Conifer	+	0	0
Other wood	10	0	+

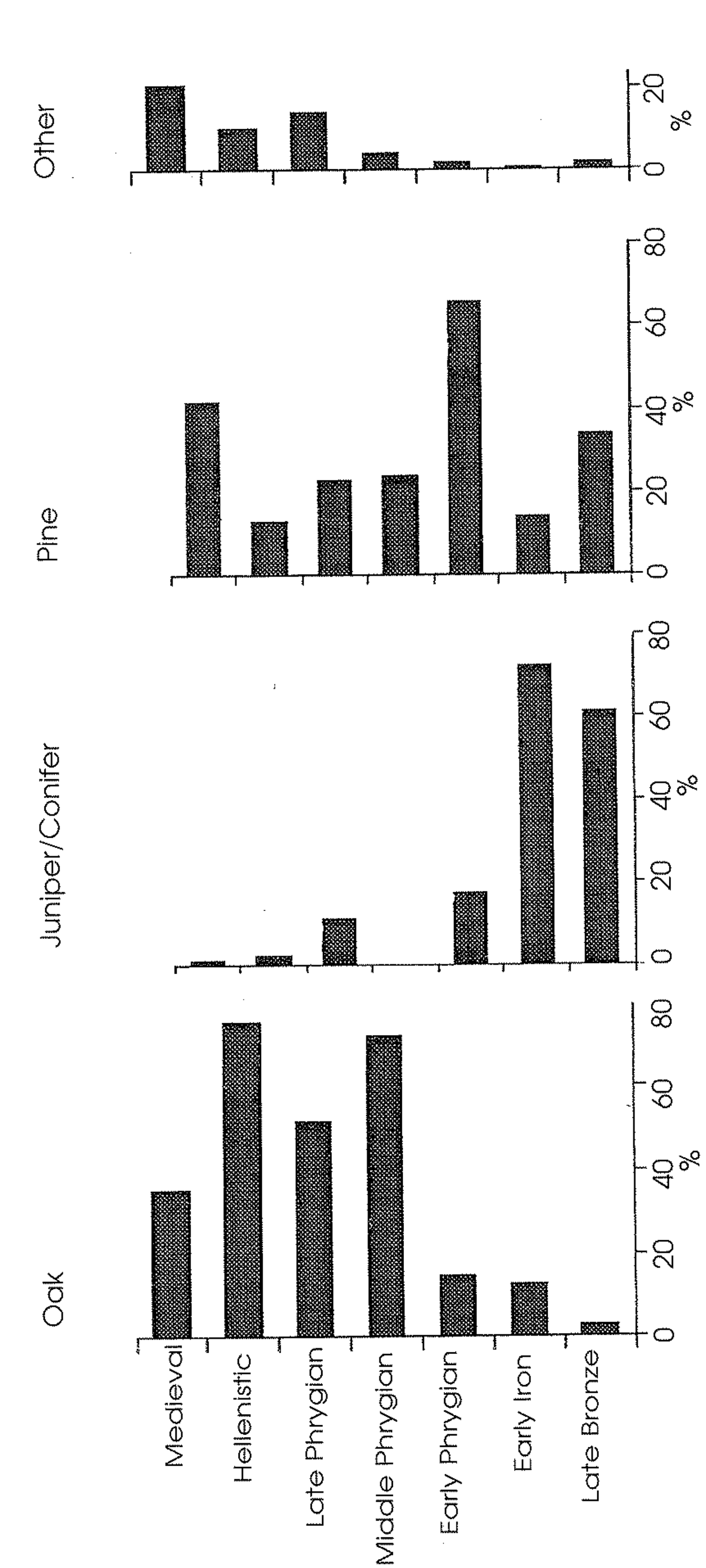
* +: present in trace amount

Table 5: Charcoal from Gordion burnt structures (% by weight)*

	Late Bronze	Early Iron	Early	Phrygian Mid	Late	Helle-nistic	Medi-eval
YH Phase	8/9	7	6	5	4	3	1
YH Phase	8	7	6B	5	4	3	1
Tot. wt.(g)	120	351	50	171	429	182	30
oak	3	13	15	72	52	75	36
pine	34	14	66	24	23	13	42
juniper/conifer*	61	72	17	0	11	2	1
other woods	2	1	2	4	14	10	21

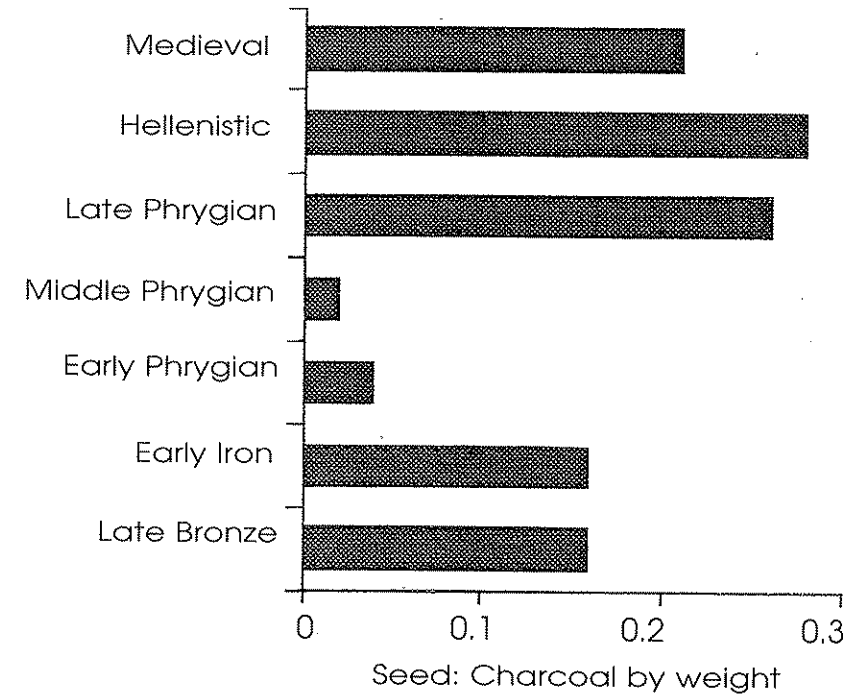
* Most "conifer" is probably juniper.

Table 6: Fuel remains from Gordion (% by weight)



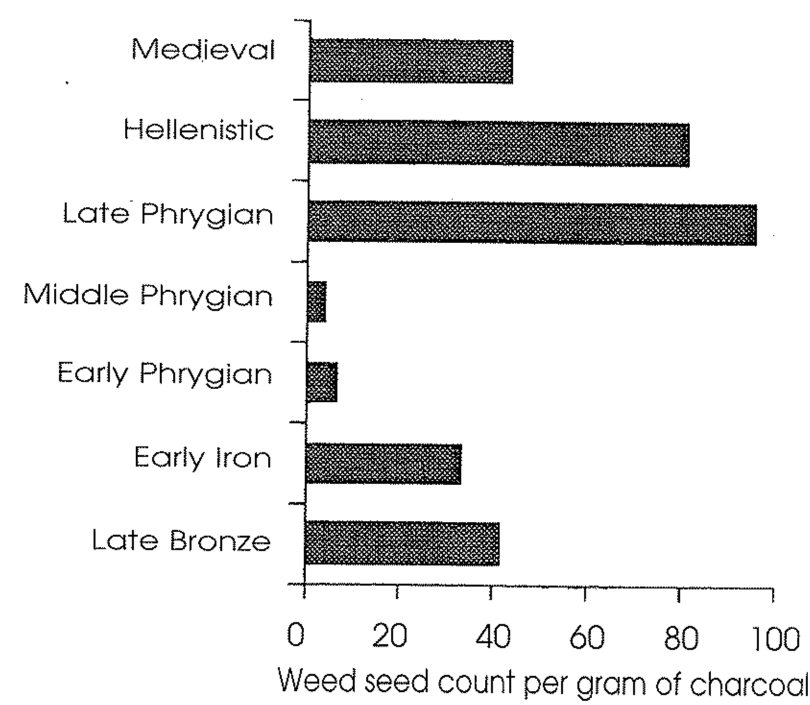
*Percentages are calculated from weighted averages based on total weight of charcoal in each phase as follows: Late Bronze (119.77 g); Early Iron (360.56 g); Early Phrygian (50.40 g); Middle Phrygian (171.29 g); Late Phrygian (429.15 g); Hellenistic (181.93 g); Medieval (29.62 g).

Figure 1: Major wood fuel types from Gordion*



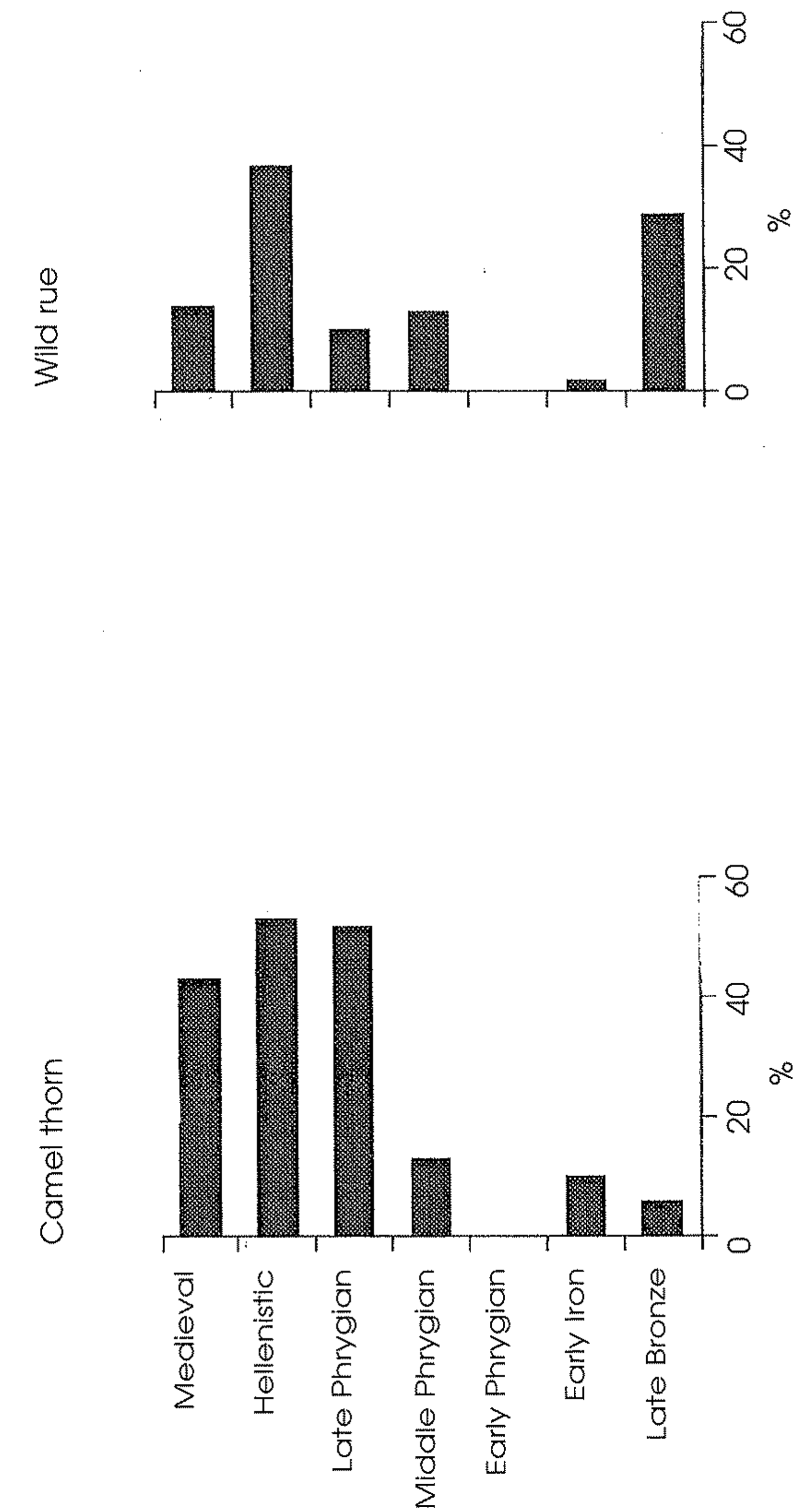
Number of samples examined: Late Bronze (17); Early Iron (42); Early Phrygian (3); Middle Phrygian (8); Late Phrygian (31); Hellenistic (19); Medieval (7)

Figure 2: Proportion of seeds to charcoal



Number of samples examined: Late Bronze (17); Early Iron (42); Early Phrygian (3); Middle Phrygian (8); Late Phrygian (31); Hellenistic (19); Medieval (7)

Figure 3: Proportion of wild seeds to charcoal



Number of samples examined: Late Bronze (17); Early Iron (42); Early Phrygian (3); Middle Phrygian (8); Late Phrygian (31); Hellenistic (19); Medieval (7)

Figure 4: Frequency of camel thorn (*Alhagi*) and wild rue (*Peganum*)