Veget Hist Archaeobot
DOI 10.1007/s00334-007-0103-0

ORIGINAL ARTICLE

Anthracological analysis from Kovacevo, southwest Bulgaria: woodland vegetation and its use during the earliest stages of the European Neolithic

Elena Marinova · Stephanie Thiebault

Received: 2 January 2006 / Accepted: 28 December 2006
© Springer Verlag 2007

Abstract Wood charcoal analysis from Kovacevo in southwest Bulgaria, one of the earliest Neolithic sites in southeastern Europe, provided information about the first stages of anthropogenic impact on vegetation during the Early Neolithic (6159–5630 cal B.C.). Deciduous oak was the most abundant and frequently used taxon in the wood charcoal assemblages. *Cornus* charcoal was also abundant, probably connected with the use of its twigs as building material in wattle and daub structures. The dominant deciduous oak forest was opened during the Kovacevo I period, as shown by evidence from the Kovacevo Ia and Kovacevo Ib occupation phases. Other types of vegetation, like Black pine (*Pinus nigra*) woodland, riverine forests and some sub-Mediterranean elements, were used only sporadically, indicating high and sustained availability of wood resources in the oak forests. Anthropogenic impacts were gradual, a pattern that matches contemporary studies elsewhere in the region.

Keywords Archaeobotany · Charcoal analysis · Plant macrofossils · Neolithic · Bulgaria

Communicated by A. Fairbairn.

E. Marinova (✉)
Department of Botany, Sofia University ''Sv. Kliment Ohridski'', 8 Dragan Tzankov blv, 1164 Sofia, Bulgaria
e-mail: elena_marinova@gmx.de

S. Thiebault
CNRS, UMR 7041, Protohistoire européenne, 21 allée de l'Université, 92023 Nanterre, France
e-mail: stephanie.thiebault@mae.u-paris10.fr

Introduction

The archaeological site of Kovacevo belongs to the earliest phases of the European Neolithic and is situated on one of the probable routes of Neolithisation through Southeast Europe. The position of the site and its age make it especially significant for investigating the earliest stages of agriculture and associated anthropogenic vegetation change. In addition, the location of the site on the northern border area between the Mediterranean and sub-continental climatic zones makes the study of vegetation change especially interesting, because of the higher sensitivity of such edge zones to changing environmental conditions.

No pollen-bearing sediments have so far been found near the site and information about past vegetation could only be gained through studying plant macrofossils recovered from the archaeological settlement layers, especially the large quantity of wood charcoal preserved there. This study presents the results of an anthracological analysis which aimed to reconstruct the woodland vegetation, its use and anthropogenic changes in the surroundings of Kovacevo during the Earliest Neolithic.

Study area

Kovacevo is situated in southwest Bulgaria, near the border with Greece. It lies on the northern valley slope of the Katunska Bistrica river (Fig. 1), which is located east of the Struma (Strymon) valley in the southern slopes of the Pirin Mountains (41°27′ N, 23°26′ E).

Natural conditions

The climate of the area is transitional between continental and Mediterranean zones, with hot dry summers and mild

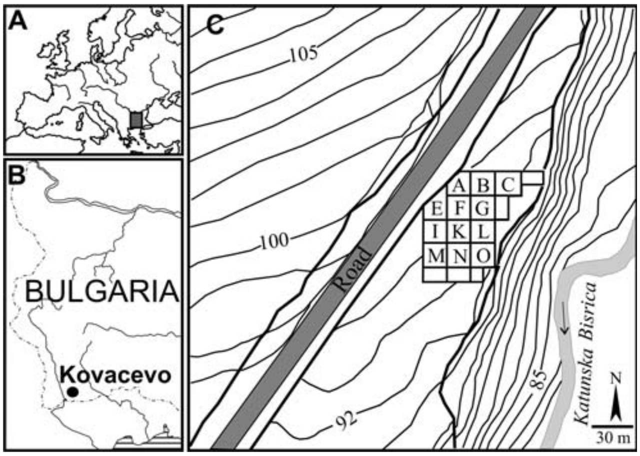

Fig. 1 Study area. **a** Map showing the location of the study area in Europe; **b** Position of the studied site in Bulgaria; **c** Excavation area

winters. Today, the mean annual temperature is about 14°C and the mean annual precipitation 700 mm. Maximum precipitation in the autumn–winter period is similar to that of the Mediterranean area, but in contrast to the Mediterranean the precipitation maximum and minimum in winter and summer are not so marked (Velev 2002). Calcareous brown soils (Cambisols) and thin stony soils (Regosols) prevail in the surroundings of the site. High erosion rates are typical because of the climatic conditions and the underlying rocks (calcareous mergel; Ninov 2002). Low winter temperatures and sporadic frosts do not allow olives to grow and limit the development of fully Mediterranean vegetation. The characteristics of the vegetation in the Pirin Mountains, on the southern slopes of which the site is situated, are determined by their altitude and by their location close to the Mediterranean area. According to Velchev (2002), seven vegetation belts can be distinguished. This paper focuses on the three lowest belts, where it is thought that anthropogenic activity was most intense during the Neolithic. The lowest belt, up to 500 m a.s.l, is today only found in fragmentary form on the southern part of the mountain and consists of communities of oaks, e.g. *Quercus pubescens* and *Q. frainetto*, with Mediterranean elements such as *Q. coccifera, Juniperus excelsa, J. oxycedrus* and *Phillyrea latifolia*. Above this, in the xerothermic oak forest at 500–700 m a.s.l., are communities of *Q. cerris, Q. pubescens, Q. frainetto* and *Carpinus orientalis*. Communities of *Q. dalechampii* and *C. betulus* are typical in the mesophilous and xeromesophilous oak-hornbeam belt (up to 800–900 or occasionally 1,000 m a.s.l.), where communities of *Pinus nigra, Ostrya carpinifolia* and *Corylus avellana* are also present.

Davis et al. (2003) reconstructed similar winter temperatures and cooler summer temperatures to those prevailing today for southeast Europe at ca. 8000 B.P. (the start of the Neolithic in the study area), probably connected with higher humidity. According to available palynological data, *Quercus*, *Ulmus*, *Tilia* and *Betula* expanded at low and middle elevations of the Pirin Mountains during the Early Neolithic (8500–8000 B.P.) in the Struma valley (Stefanova and Ammann 2003). Enlargement of the deciduous oak forests is a sign of increasing humidity and milder climatic conditions parallel to the arrival of the first farmers in the area.

Archaeological setting

Three main periods of occupation of the Kovacevo site were defined: Kovacevo I, Early Neolithic; Kovacevo II, Middle Neolithic; Kovacevo III, Early Bronze Age (Demoule and Lichardus-Itten 1994). Kovacevo I represents the earliest Neolithic presence in Bulgaria. Available radiocarbon dates (Table 1) place Kovacevo I between 6159 and 5630 cal B.C.. The Early Neolithic phase covers a surface area of about 5–6 ha and does not form the classic tell found in neighbouring areas in Greece and Bulgaria, but rather is an extensive settlement with up to two metres of cultural deposit (Lichardus-Itten et al. 2002).

Four Early Neolithic occupation phases were established (Table 1, after Lichardus-Itten et al. 2002), the latest (Karanovo Id) being contemporary with the Karanovo I culture (Nikolov 1996, 2000). Two additional earlier and relatively autonomous settlement phases could be observed, Kovacevo Ia and Ib, which show connections with Northern Greece (Giannitsa, Nea-Nikomedea) and the Macedonian Republic (Anzabegovo, Velusina) (Perniceva 1995; Lichardus-Itten et al. 2002).

Materials and methods

This research is based on the study of 1,486 wood charcoal fragments from archaeological features in Kovacevo I. Wood charcoal was sampled by manual collection, dry sieving (608 fragments) and flotation (878 fragments). The number of archaeological contexts from which the studied charcoal originates is given in Table 2.

Preservation conditions

Plant remains were recovered from excavations covering an area of ca. 1,600 m^2 (Fig. 1c). The overall concentration of identifiable plant material in cultural layers was low compared to other sites in the region. For example, only 3.27 identifiable seeds/fruits (dominated by chaff of hulled wheat) were recovered per litre of floated sediment, while in many other Bulgarian sites seed/fruit concentration was about 11–15 items per litre of soil (Marinova 2006). In

Table 1 Chronological scheme for the Early Neolithic of Kovacevo and the neighbouring regions (after Lichardus-Itten et al. 2002) and radiocarbon dates from Kovacevo according to Evin (2002)

Lab. Nr.	Year B.P.	Cal B.C.	Kovacevo	North Greece	SW Bulgaria	Thrace
Early Neolithic						
LY-6554	6830 ± 85	5790–5630	Kovacevo Id		Kovacevo	Karanovo II
			Kovacevo Ic		Dobriniste	Karanovo I
LY-1438 (OXA)	6990 ± 45	5984–5733	Kovacevo Ib	Nea Nikomedeia	Eleshnica	
LY-1437 (OXA)	7180 ± 45	6159–5926	Kovacevo Ia	Giannitsa		

Table 2 Number of archaeological contexts studied—manual collecting, dry sieving and flotation samples from Kovacevo

	Manual collecting, dry sieving				Flotation			
Kovacevo periods:	I	Ia	Ia/Ib	Ib	I	Ia	Ia/Ib	Ib
Layer	20	3	1	1	7	1	4	2
Floor	2	10	3	1	1	–	–	–
Post hole	4	2	–	2	–	–	–	–
Daub	2	–	1	–	–	–	–	–
Conc. of stones	1	–	–	–	–	–	–	–
Trench	1	–	1	3	1	–	–	–
Pit	5	2	3	–	4	–	2	1
Well	1	–	–	–	–	–	–	–
House	–	2	2	2	4	2	5	4
Concrete	–	–	–	1	–	–	–	–
Total	36	19	11	10	17	3	11	7
Volumes (l)	–	–	–	–	525	165	412	395

addition, after more than 14 excavation seasons at Kovacevo, neither storage finds nor other contexts preserving high concentrations of plant remains were recovered. The wood charcoal was also badly preserved and highly fragmented (usually smaller than 0.5 cm), which in many cases made the taxonomic determination quite difficult. The concentration of identifiable wood charcoal fragments in the flotation samples was less than three items (2.86 identifiable fragments) per litre.

Laboratory methods

Plant material was studied using reflected light microscopy, both light- and dark-field. Fragments were broken manually to expose transverse, tangential-longitudinal and radial-longitudinal sections. Taxonomic determinations were made using the reference collection of the Archaeobotany and Palaeoecology laboratory, UMR 7041 CNRS, and published works on wood anatomy (Jacquiot et al. 1973; Schweingruber 1990). The material was not weighed as, according to Chabal (1997), the biomass representation of charcoal does not differ greatly whether the pieces are counted or weighed.

Interpretative methods

Charcoal dispersed in the occupation levels gives a more representative sample of the vegetation over a longer time span than does charcoal concentrated in archaeological features such as burnt layers, hearths and fire pits that resulted from short-term burning events (Heinz and Thiébault 1998). The material studied from Kovacevo represents the preserved remains of burning activities carried out over extended periods of occupation as it generally originates from occupation layers, floors, houses and pits (Table 2). Interpretation was based on the counts and percentage proportions of identified charcoal fragments. Reconstructions of the ancient vegetation were made with reference to the potential natural vegetation of the region after Bondev (1991) and Bohn et al. (2000/2003).

Results

The results of the anthracological analysis are presented in Table 3 as counts and percentage proportions of charcoal fragments. Figure 2 shows graphically the percentage

Table 3 Results of the wood charcoal analysis for the period Kovacevo I

Kovacevo (EN)	I (undiff.)		Ia		Ia/Ib		Ib		I (sum)	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Riverine forests										
Alnus sp.	9	1.7	–	–	–	–	–	–	9	0.6
cf. *Populus*	2	0.4	–	–	–	–	–	–	2	0.1
Ulmus sp.	4	0.7	2	0.5	1	0.4	6	2.3	13	0.9
Deciduous oak forests										
cf. *Acer*	3	0.6	–	–	1	0.4	–	–	4	0.3
cf. *Carpinus betulus/orientalis*	1	0.2	–	–	–	–	–	–	1	0.1
Fraxinus excelsior/ornus	1	0.2	–	–	–	–	2	0.8	3	0.2
cf. *Fraxinus excelsior/ornus*	–	–	–	–	1	0.4	6	2.3	7	0.5
Quercus deciduous	388	71.7	357	80.8	171	70.4	192	73.8	1108	74.6
Pomoideae	14	2.6	1	0.2	4	1.6	–	–	19	1.3
cf. *Sorbus/Crataegus*	17	3.1	12	2.7	–	–	–	–	29	2.0
Deciduous oak forests-undergrowth/edges										
Cornus sp.	62	11.5	37	8.4	45	18.5	41	15.8	185	12.5
Corylus avellana	3	0.6	2	0.5	2	0.8	–	–	7	0.5
Prunus sp.	1	0.2	2	0.5	–	–	–	–	3	0.2
Rosaceae	3	0.6	2	0.5	2	0.8	2	0.8	9	0.6
Mediterranean/Submediterranean elements										
cf. *Arbutus unedo*	–	–	1	0.2	–	–	–	–	1	0.07
cf. Fabaceae	–	–	11	2.5	–	–	–	–	11	0.74
cf. *Juniperus*	1	0.2	–	–	–	–	–	–	1	0.1
cf. *Quercus*–evergreen	2	0.4	2	0.5	–	–	1	0.4	5	0.3
Pinus nigra/sylvestris	15	2.8	3	0.7	11	4.5	8	3.1	37	2.5
Coniferous	2	0.4	–	–	–	–	–	–	2	0.1
Others										
Angiosperms	9	1.7	8	1.8	1	0.4	–	–	18	1.2
Indet	3	0.6	–	–	4	1.6	2	0.8	9	0.6
Total number	541		442		243		260		1486	

n number of wood charcoal pieces

proportions of the main vegetation types identified in the wood charcoal assemblages of Kovacevo I. The *Quercus*-deciduous charcoal indicated in Table 3 is thought to come from the *Quercus* species most common today in the area, i.e. *Q. cerris, Q. pubescens* or *Q. frainetto*.

Four samples manually collected from post holes contained only deciduous oak charcoal. This evidence led us to the conclusion that the posts were made of oak, hence the four samples are considered as one unit in the table of results. Other monospecific samples taken by manual collection and dry sieving originate from daub, trenches, floors and a well. The two daub samples contained fragments of Pomoideae and deciduous oak, respectively. Four trenches contained only oak and one an indeterminate coniferous species. One floor sample contained Pomoideae and the other one oak. The well contained only oak. As in the case of the postholes, these occurrences were recorded as single fragment in the table of results. Of the ten samples taken from the period 1a floors, six contained only oak charcoal. Samples attributed to the transition 1a/1b were all monospecific, except for those from the daub. A similar pattern was observed in samples from 1b, where all samples were monospecific, with the exception of samples from house 617.

Flotation samples usually contained a wider range of taxa than the manually collected samples, especially samples from layers, houses and pits. In the flotation samples, the dominant taxa were deciduous oak (occurring in all of the flotation samples) and cornel (*Cornus*, occurring in almost all of the flotation samples 36 out of 38). The quantity and frequency of *Cornus* charcoal probably reflects the abundance of this tree in the area, but its hard and compact wood may have been preferentially preserved in the poor taphonomic conditions of the site.

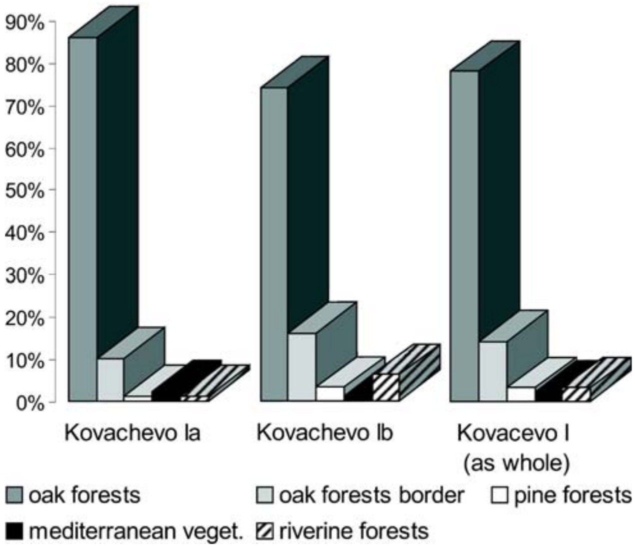

Fig. 2 The main wood vegetation types presented for Kovacevo I according to the results of the wood charcoal analysis

Considering the identified taxa and the potential natural vegetation of the region we suggest that three vegetation types were mainly used during the Neolithic of Kovacevo: deciduous oak forests, pine stands and riverine forests. There were also traces of Mediterranean vegetation, probably growing in open places in the area or as sub-Mediterranean elements of the open oak forests. In all of the contexts studied the prevailing taxon was deciduous oak, which points to a high availability of deciduous oak forest during the Early Neolithic. We suggest that oak forests dominated the surroundings of the site, corresponding to the potential contemporary natural vegetation in the area. Today these forests have been widely replaced by agricultural areas or have been degraded by grazing. About 17% of the wood charcoal assemblage belonged to light-demanding species, such as *Cornus mas*, *Corylus a-vellana* and *Prunus* sp., which also grow in the deciduous oak forest. In our interpretation, we consider that they grew on the forest edge and as undergrowth in some of the more open stands of the oak forests. These light- demanding species increased from the Kovacevo Ia to Kovacevo Ib phases. The same tendency was observed in the pine woods and riverine forests. No increase in the representatives of Mediterranean vegetation was observed (Fig. 2). The wood of evergreen oak (*Quercus*-evergreen) found in the settlement layers probably originated from *Quercus coccifera*. *Pistacia terebinthus*, *Carpinus orientalis* and *Cornus mas*, all represented by their fruits, are light demanding species which could have grown in the understorey of oak forests or openings in the canopy that provided favourable conditions for their growth. Some of the sub-Mediterranean elements, such as *Juniperus oxycedrus*, *Carpinus orientalis*, *Quercus coccifera* and *Pistacia terebinthus*, today belong to the natural undergrowth of the oak forests of the region and could have also grown as natural elements in oak forests during the period studied.

Discussion

In Table 4 the results of the charcoal analysis are given together with those from carpological studies (Marinova 2006) relevant for understanding the past vegetation around the site.

Vegetation during the Early Neolithic (6159–5630 cal B.C.)

The present study shows that extensive light deciduous oak forest dominated the surroundings of Kovacevo. This forest constituted the main natural vegetation of the area. Today, similar forests are composed mainly of xerothermic oak species, like *Quercus pubescens*, *Q. cerris* and *Q. frainetto*, mixed with other species such as *Carpinus orientalis*, *Fraxinus ornus* and *Acer campestris*. Numerous small tree and shrub species could grow in the rich undergrowth, such as *Sorbus domestica*, *S. torminalis*, *S. aria*, *Acer hyrcanum*, *A. tataricum*, *Pyrus pyraster*, *Crataegus monogyna*, *Cornus mas*, *Corylus avellana*, *Ostrya carpinifolia*, *Paliurus spina-christi*, *Phillyrea latifolia*, *Juniperus oxycedrus, Pistacia terebinthus* and *Colutea arborescens*. Some of these taxa—determined to genus level—were possible components of the wood charcoal record (Table 3) and several were identified in the seed/fruit assemblage (Table 4). In these forests the prevailing plant species are those with Mediterranean and sub-Mediterranean distribution, mixed with smaller quantities of temperate and middle European species. Considering this, the oak forests developed around the site were the most probable source of the evidence for sub-Mediterranean elements in the wood charcoal record. The sub-Mediterranean elements today are quite well represented in the surroundings due to favourable anthropogenic influence. These taxa formed only 1–2% of the material studied (Table 3, Fig. 2), suggesting that during the Neolithic sub-Mediterranean vegetation was not itself widely spread around Kovacevo, but some of its elements occurred in the oak forests. Sub-Mediterranean elements could also have developed natural extra-zonal ''islands'' in places where the dominance of the zonal vegetation (deciduous oak forests) was reduced by the combination of thin soils and exposure on south-facing slopes (Horvat et al. 1974). The traces of Mediterranean vegetation found could have grown in similar open places as the sub-Mediterranean elements, such as slopes where the soil conditions were favourable. Evergreen oaks (*Quercus coccifera*) and red juniper (*Juniperus oxycedrus*) today grow near the

Table 4 Presence/absence of tree and shrub taxa according to wood charcoal and carpological studies

Kovacevo (Early Neolithic)	I		Ia		Ia/Ib		Ib	
	Wood	Fruit/seed	Wood	Fruit/seed	Wood	Fruit/seeds	Wood	Fruit/seed
Riverine forests								
Alnus sp.	+	+	–	–	+	–	–	–
cf. *Populus* sp.	+	–	–	–	–	–	–	–
Sambucus ebulus	–	+	–	–	–	–	–	–
Sambucus sp.	–	+	–	+	–	+	–	+
Ulmus sp.	+	–	+	–	+	–	+	–
Vitis vinifera ssp. *sylvestris*	–	+	–	+	–	+	–	+
Deciduous oak forests								
cf. *Acer* sp.	+	–	–	–	–	–	–	–
cf. *Carpinus betulus/orientalis*	+	–	–	–	–	–	–	–
Fraxinus excelsior/ornus	–	–	–	–	–	–	+	–
cf. *Fraxinus excelsior/ornus*	+	–	+	–	+	+	+	+
Prunus sp.	+	+	+	+	–	+	–	+
Pomoideae	+	–	+	–	+	–	–	–
Quercus–deciduous	+	–	+	–	+	–	+	–
Sorbus aucuparia	–	+	–	–	–	–	–	–
cf. *Sorbus/Crataegus*	+	–	+	–	–	–	–	–
Rosaceae	+	–	+	–	+	–	+	–
Deciduous oak forests-undergrowth/edges								
Cornus sp.	+	+	+	+	+	+	+	+
Corylus avellana	+	+	+	+	+	+	+	+
Prunus cf. *spinosa*	–	+	–	+	–	+	–	–
Prunus sp.	+	+	+	+	–	+	–	+
Rosa sp.	–	–	–	–	–	–	–	+
Rubus fruticosus s.l.	–	+	–	–	–	+	–	+
Rubus sp.	–	+	–	+	–	+	–	–
Mediterranean/sub-Mediterranean elements								
cf. *Arbutus unedo*	–	–	+	–	–	–	–	–
Carpinus orientalis	–	+						
cf. Fabaceae	–	–	+	–	–	–	–	–
cf. *Juniperus*	+	–	–	–	–	–	–	–
Pinus nigra/sylvestris	+	+	+	–	+	+	+	–
Pistacia terebinthus	–	+	–	–	–	–	–	–
cf. *Quercus*–evergreen	+	–	+	–	–	–	+	–

site and form a pseudo-maquis thought to have developed under the influence of anthropogenic vegetation change, especially intense use of pasture in the area (Bondev 1991).

The increase in light demanding species between phases Ia and Ib, included here in the ''deciduous oak forests undergrowth/edges'' group, could also be an indication of anthropogenically induced changes in oak forest composition. A taxon which may indicate this tendency is *Cornus*, which was fairly well represented by both fruits and charcoal fragments (12.5% of the whole wood charcoal record). It is difficult to know which cornel species was used as the wood of *C. mas* and *C. sanguinea* is anatomically indistinguishable (Schweingruber 1990). Fruit stones of both species occurred in the Kovacevo macrofossil record, but *C. mas* was dominant, being present in almost every sample, as compared with only two specimens of *C. sanguinea* in the whole Early Neolithic record. Both the abundance of *C. mas* fruit stones and its wide modern distribution in the area suggest that it may have been the source of the wood charcoal. Perhaps the frequent occurrence of *Sambucus* fruits (in most cases *S.* cf. *ebulus*) indicates not only riverine forests, but also anthropogenic activities such as opening of the vegetation and ruderalisation of habitats. Other taxa which could belong to open parts of the forests were *Rubus* sp. and *Prunus spinosa*, both present throughout the whole period settlement at Kovacevo I.

Pine in the samples probably came from the sub-Mediterranean element Black or Austrian pine (*Pinus nigra*) which today grows from 200 to 1,600 m a.s.l. mainly on calcareous soils in the area. The finds indicate the development of pine stands near the site, which were probably easily reached by the inhabitants of the settlement. The finds of woody Fabaceae may have come from species growing in the undergrowth of the Black pine or oak forests, such as *Genista* and *Chamaecytisus* species, which grow in the pine woodland or *Colutea arborescens, Coronilla emerus* and *Astragalus cicer*, which are elements of the undergrowth of the oak forests. Black pine and some other sub-Mediterranean elements increased during the development of the Kovacevo I settlement, perhaps because of enlargement of the activity zone around the site.

Some taxa which could grow in several vegetation types should also be mentioned. Firstly, the *Fraxinus* sp. could have derived from either *Fraxinus ornus*, a sub-Mediterranean element belonging to the undergrowth of the oak forests, or *F. excelsior*, which grows in the riverine forests. Hazel (*Corylus avellana*) occurred sporadically in both the wood charcoal and carpological records and may have grown in the undergrowth of both the oak and riverine forests. However the small quantity of wood and fruits found (5 specimens in more than 1,000 l of sediment) probably resulted from its sparse occurrence in the area. Elm (*Ulmus* sp.) and maple (*Acer* sp.) could have originated from the transitional area between the riverine forests and the oak forests.

Use of the vegetation

The most abundant and frequently used wood was deciduous oak. The deciduous oaks prevailing in the vegetation of the area were obviously used for fuel and building materials. Wood charcoal of species from outside oak forests was present in very low quantities. This probably indicates that the oak forests were well developed and extensive enough to cater for most wood needs, making it unnecessary to enlarge the area exploited to supply wood. According to the analysis of burnt posts oak was one of the main woods used for building material. In all published anthracological studies from Bulgarian Neolithic sites (Galabnik and Kremenik, Marinova et al. 2002, and Rakitovo, Cakalova and Bozilova 2002) the dominantly used wood species was the deciduous oak. Also widely used during the Early Neolithic in Kovacevo was *Cornus*, which was second in abundance and ubiquity to the oak. The supple and tough twigs of *Cornus* may have been the preferred building material used in wattle and daub constructions. A similar pattern of abundance was found in the Early Neolithic layers of Kremenik (Marinova et al. 2002).

The relatively high number of wood charcoal fragments from light demanding taxa could be an indication of the presence of managed hedges created by the Neolithic inhabitants for both field protection and firewood production (Kreuz 1990). The high availability of wood resources in the deciduous oak forest was probably the main reason why riverine forest may have been used only sporadically, as shown by the low percentage values of their wood charcoal recovered from Kovacevo I as a whole (<3%, Fig. 2).

Fruits of several woody species were also preserved with the wood charcoal, the most numerous being *Cornus mas*. Plum stones were also common, including the rough-surfaced *Prunus* cf. *spinosa* and fragments with a smoother surface, probably from *Prunus cerasifera.* The wood of *Vitis vinifera* did not appear in the wood charcoal record but its fruits were quite frequent in the Early Neolithic layers of Kovacevo. In all cases these were fruits of the wild vine *Vitis vinifera* subsp. *sylvestris*. Although deciduous oaks were the most widely used wood species, there was no evidence of acorns being utilised. The use of the acorns in the region is widely recorded in Neolithic sites in Northern Greece (Valamoti 2004). The lack of acorns in the macrofossil record in Kovacevo probably reflects the poor preservation conditions at the site (see above), rather than a real absence of the fruits.

Implications for land management during the Early Neolithic in southeast Europe

For the European Neolithic in general, the prevalent form of woodland management is thought to be ‘‘leaf-fodder husbandry’’, characterised by small scale clearings just large enough for the settlements and small fields (Behre 1988). A large amount of palynological and sedimentological evidence from Central Europe has demonstrated that, in spite of the woodland clearances, Early Neolithic life remained strongly adapted to and utilised the forest ecosystem (Kalis et al. 2003). Geochemical and palynological evidence from the Hungarian Neolithic and Copper Age suggests that soil erosion was not occurring and forest use was expressed through a woodland management regime similar to coppicing or pollarding (Gardner 2002). Evaluating the palynological evidence from the Neolithisation of the Balkan peninsula, Willis and Bennett (1994) found that human impact is almost invisible in the palynological record. One possible explanation for this is the small scale of that impact. Alternatively, human impact might also have been of a character that is difficult to identify through pollen analysis. It should also be stressed that most palynological information on land management and land use in south east Europe comes, because of the preservation conditions in the region, from sites located in the mountains. Therefore, there is almost no detailed information from the lowlands and the mid- to low-altitudes, where the most of the Neolithic sites are situated. Results from Kovacevo provide important evidence that extends the knowledge of land use in the lower altitudes of the mountains and tests existing land use models by direct analysis of that evidence. The results suggest that Neolithic subsistence did not drastically disturb the woodland vegetation surroundings of the site, as indicated by the high and sustained availability of resources from oak forests, and limited use of other habitats. Like the data from Kovacevo, the analysis of wood charcoal assemblages from the Neolithic Anatolian site of Çatalhöyük (Asouti and Hather 2001; Fairbairn et al. 2002) suggests that woodland subsistence management was sustainable for several centuries. A pattern of increase in the abundance of light demanding species, similar to that seen in Kovacevo, was also observed in Late Neolithic wood charcoal assemblages from northern Greece (Ntinou and Badal 2000). The evidence from Kovacevo of more intense use of wood and fruits from light demanding shrubs points to the possible maintenance and management of hedges observed for elsewhere for the Linearbandkeramik (Kreuz 1990). As well as being useful for obtaining firewood, fodder and fruit, hedges containing spiny species such as *Rubus* and *Rosa* would provide good protection of fields from grazing domestic animals. On the other hand, mineralised *Rubus* nutlets in sheep/goat-coprolites from Kovacevo confirm the use of the forest edge for grazing. It is possible that the forest contained a mosaic of openings that facilitated the development of light demanding shrubs over a larger area. Another indirect indicator of the presence of small open areas may come from evidence of wheat harvesting by ear-plucking, which was still important during the Bulgarian Neolithic (Kreuz et. al. 2005). Usually this harvesting method is connected with smaller scale cultivation, as observed from ethnographic evidence (Peña-Chocarro 1999), and thus its presence may indicate the existence of small-scale agriculture in the Bulgarian Neolithic. Fuller investigation of this hypothesis is beyond the scope of this work, as the wood charcoal data could not provide definitive information on neither the degree of forest opening, nor the scale of the cultivated fields.

Conclusion

Results of anthracological studies showed that during the Early Neolithic (6159–5630 cal B.C.) the vegetation in the area of Kovacevo was dominated by open deciduous oak forests. This forest was the most widely used vegetation during the period studied, although riverine forests and pine stands, probably in close proximity to the site, were also reachable by the Neolithic population. Land use and management by early Neolithic communities in the region favoured the opening of forested areas and lead to an increase in area of forest edge zones and secondary forests. Such changed habitats were useful for grazing animals, collecting fruits, fodder, firewood and the protection of arable fields. Hence the subsistence practices adopted by Neolithic farmers subtly shaped the wooded landscape with only slight and gradual changes in forest composition and transition to secondary forest and managed hedges of variable extent.

Acknowledgments The authors thank the excavators Marion Lichardus-Itten, Jean-Paul Demoule, Małgorzata Grebska-Kulova and Ilia Kulov for providing invaluable support through many years in obtaining the material studied. Part of this study was carried out through a scholarship from the French Centre National de Recherche Scientifique. Also we would like to thank Dessislava Gyurova, Angela Kreuz, two anonymous referees and Andrew Fairbairn for invaluable comments and helpful suggestions.

References

Asouti E, Hather J (2001) Charcoal analysis and the reconstruction of ancient woodland vegetation in the Konya Basin, south-central Anatolia, Turkey: results from the Neolithic site Catalhöyük East. Veget Hist Archaeobot 10:23–32

Behre K-E (1988) The role of man in European vegetation history. In: Huntley B, Webb T (eds) Vegetation history. Kluwer, Dordrecht, pp 633–672

Bohn U, Gollub G, Hettwer C, Neuheuslová Z, Schlüter H, Weber H (2000/2003) Map of the natural vegetation of Europe. Scale: 1:2,500,000, Parts 1, 2 and 3. Landwirtschaftsverlag, Bonn

Bondev I (1991) The vegetation of Bulgaria. Map 1:600 000 with explanatory text. St. Kliment Ohridski University Press, Sofia (in Bulgarian with English summary)

Cakalova E, Bozilova E (2002) Paleoekologicni i paleoethnobotanicni materiali ot selistnata mogila do gr. Rakitovo [Palaeoecological and paleoethnobotanical materials from the tell settlement near town Rakitovo]. In: Radunceva A et al. (eds) Neolitnoto seliste do grad Rakitovo, Razkopki i proucvanija 29:191–201

Chabal L (1997) Forêts et sociétés en Languedoc - Néolithique final, Antiquité tardive, L'anthracologie, méthode et paléoécologie. Documents d'Archéologie Française 63, Paris

Davis B, Brewer S, Stevenson A, Guiot J, Data Contributors (2003) The temperature of Europe during the Holocene reconstructed from pollen data. Quat Sci Rev 22:1701–1716

Demoule JP, Lichardus-Itten M (1994) ''Fouilles franco-bulgares du site néolithique ancien de Kovacevo (Bulgarie du sud-ouest).'' Bull Correspond Hell 118:561–618

Evin J (2002) Datations absolutes. In: Demoule JP, Lichardus-Itten M (eds) Kovacevo 2001. Fouilles néolithiques franco-bulgares dans la valée du Strymon. Rapport annuelle miméographieque, Université de Paris 16:28–29

Fairbairn A, Asouti E, Near J, Martinoli D (2002) Macro-botanical evidence for plant use at Neolithic Çatalhöyük south-central Anatolia, Turkey. Veget Hist Archaeobot 11:41–54

Gardner A (2002) Neolithic to Copper Age woodland impacts in northeast Hungary? Evidence from the pollen and sediment chemistry records. Holocene 12:541–453

Heinz C, Thiébault S (1998) Characterization and palaeoecological significance of archaeological charcoal assemblages during Late and Post-Glacial phases in Southern France. Quat Res 50:56–68

Horvat I, Glavac V, Ellenberg H (1974) Vegetation Südosteuropas. In: Tüxen R (ed) Geobotanica selecta. Fischer, Stuttgart

Jacquiot C, Trenard Y, Dirol D (1973) Atlas d'anatomie des bois des Angiospermes. Centre Technique du Bois, Paris

Kalis AJ, Merkt J, Wunderlich J (2003) Environmental changes during the Holocene climatic optimum in central Europe—human impact and natural causes. Quat Sci Rev 22:33–79

Kreuz A (1990) Die ersten Bauern Mitteleuropas - eine archäobotanische Untersuchung zu Umwelt und Landwirtschaft der Ältesten Bandkeramik. Analecta Praehistorica Leidensia 23. University Press, Leiden

Kreuz A, Marinova E, Schäfer E, Wiethold J (2005) A comparison of early Neolithic crop and weed assemblages from the Linearbandkeramik and the Bulgarian Neolithic cultures: differences and similarities. Veget Hist Archaeobot 14:237–258

Lichardus-Itten M, Demoule JP, Perniceva L, Grebska-Kulova M, Kulov I (2002) The site Kovacevo and the beginnings of the Neolithic period Southwestern Bulgaria. In: Lichardus-Itten M, Lichardus J, Nikolov V (eds) Beiträge zu jungsteinzeitlichen Forschungen in Bulgarien. Saarbrücker Beiträge zur Altertumskunde 74. Habelt, Bonn, pp 99–156

Marinova E (2006) Vergleichende paläoethnobotanische Untersuchung zur Vegetationsgeschichte und zur Entwicklung der prähistorischen Landnutzung in Bulgarien. Diss Bot 401, Cramer, Berlin Stuttgart

Marinova E, Tchakalova E, Stoyanova D, Grozeva S, Doceva E (2002) Ergebnisse archäobotanischer Untersuchungen aus dem Neolithikum und Chalcolithikum in Südwestbulgarien. Archaeol Bulg 6:1–11

Nikolov V (1996) Jugozapaden variant na kultarata Karanovo I [Southewestern variant of the culture Karanovo I]. Archeologia 38:1–8

Nikolov V (2000) Neolithische Keramikkomplexe in Thrakien. In: Hiller S, Nikolov V (eds) Karanovo, Band III. Phoibos Verlag, Wien, pp 11–19

Ninov N (2002) Soils. In: Kopralev IE (eds) Geography of Bulgaria. Physical geography. Socio-economic geography. ForComPublishers, Sofia, pp 227–316 (in Bulgarian with English summary)

Ntinou M, Badal E (2000) Local vegetation and charcoal analysis: an example from two late neolithic sites in Northern Greece. In: Halstead P, Frederick C (eds) Landscape and land use in postglacial Greece. Sheffield Academic Press, Sheffield, pp 38–51

Peña-Chocarro L (1999) Prehistoric agriculture in Spain. The application of ethnographic models. BAR International Series 818. Archaeopress, Oxford

Perniceva L (1995) Prehistoric cultures in the Middle Struma Valley: Neolithic and Eneolithic. Prehistoric Bulgaria. In: Bailey D, Panayotov I (eds) Praehistoric Bulgaria. Monographs in World Archaeology 22:99–140

Schweingruber F (1990) Anatomie europäischer Hölzer. Ein Atlas zur Bestimmung europäischer Baum-, Strauch- und Zwergstrauchhölzer. Haupt, Bern Stuttgart

Stefanova I, Ammann B (2003) Lateglacial and Holocene vegetation belts in the Pirin Mountains (southwestern Bulgaria). Holocene 13:97–107

Valamoti SM (2004) Plants and people in Late Neolithic and Early Bronze Age Northern Greece: an archaeobotanical investigation. BAR International Series S1258. Archaeopress, Oxford

Velchev V (2002) Characteristic features and regularities in the distribution of the present-day vegetation. In: Kopralev I (ed) Geography of Bulgaria. ForComPublishers, Sofia, pp 312–324 (in Bulgarian with English summary)

Velev S (2002) Climate regioning. In: Kopralev I (ed) Geography of Bulgaria. ForComPublishers, Sofia, pp 155–157 (in Bulgarian with English summary)

Willis KJ, Bennett KD (1994) The Neolithic transition - fact or fiction? Palaeoecological evidence from the Balkans. Holocene 4:326–330