

# LATE QUATERNARY VEGETATION HISTORY OF NORTHERN TURKEY\*

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**ABSTRACT:** The reconstruction of vegetation and climate for the Late Glacial and Holocene period of northern Turkey is discussed in the light of the palynological examination of surface samples and sediment cores. Aspects of geology, geography, climate and present or natural vegetation are discussed in sections 3, 4 and 5.

The modern pollen precipitation of the area is treated on the basis of 40 surface samples from natural as well as from severely degraded vegetations. An attempt has been made to explain the share of some types, including *Juglans*, *Pistacia*, *Pinus*, *Juniperus* and *Plantago lanceolata* in the modern pollen precipitation.

Table 5 represents the time covered by the sediment samples for this study, which originate from Abant, Yeniçağa, Melen, Küçük Akgöl (Sakarya), Adatepe (Sakarya), Seyfe, Tuzla, Demiryurt (Hafik), Büyük Gölü (Hafik), Kaz, Lâdik and Tatlı. The diagrams of Abant, Yeniçağa and Lâdik Gölü indicate that cold and dry conditions prevailed in the period from 14,000 to 10,000 BP. *Artemisia* and other steppic plants were dominant and a small number of trees occurred on edaphically favourable spots. The Late Glacial and its sub-phases resemble those of Europe.

At the beginning of the Postglacial, forest immediately conquered the mountain ranges of northern Turkey. In the higher zone a pioneer forest of birch and maple appeared at first, to be followed by deciduous oak, hornbeam, hazel and (Nordmann) fir. Somewhat later, beech started to spread over the mountains, especially in the eastern parts (Lâdik). After 7000 BP an increase in pine is deduced from the high pollen values of this taxon.

The climatic developments of this part of Turkey more closely resemble those of Europe than those of southern Turkey. Seven diagrams inform us about the impact of man during the 2nd millennium BC. The evidence tallies well with the so-called Beyşehir Occupation phase of southwestern Turkey.

The pollen evidence pointing to human interference with the vegetation, at the altitude of for instance Abant Gölü, must be ascribed to long-distance transport, because several of the pollen producers (*Olea*) cannot have grown at 1300 m. The influence of prehistoric man upon the vegetation in northern Turkey is treated also in the final section.

**KEYWORDS:** Northern Turkey, palynology, vegetation history, palaeoclimate, prehistory, archaeology.

## 1. INTRODUCTION

The aim of this study is to reconstruct the vegetation of northern Turkey during the Late Quaternary period by means of palynology. The present study is an attempt to extend our knowledge on the Anatolian Late Glacial and Holocene record. Reports on this subject earlier appeared in van Zeist et al. (1967, 1975), van Zeist & Woldring (1980) and Bottema & Woldring (1984 (1986)). Part of the information discussed in this paper has appeared in a concise form in van Zeist & Bottema (1991).

Since our last publication on the Late Quaternary vegetation record of a part of Turkey (Bottema & Woldring, 1984 (1986)), information on the modern vegetation of Turkey has increased considerably. For this the reader is referred to van Zeist & Bottema (1991).

The development of early prehistoric agriculture as well as initial urbanization did not take place in northern Turkey. Environmental investigations were therefore

started later in the north than in other parts of Anatolia and the Near East where they were included in archaeological research. The filling in of blanks on the palaeobotanical and palaeoclimatical map of Anatolia serves an important archaeological purpose. Abiotic features, and climatic and the subsequent vegetational development were of crucial importance for the spread of prehistoric population. The directions that early prehistoric farming took from the initial Fertile Crescent were defined to a large extent by the situation in neighbouring areas. The mainstream of events certainly went around the heavily wooded parts of northern Turkey. This habitat did not meet the requirements of the crops of prehistoric people or the people lacked the technical skills to cope with this environment. There are many possible reasons why early farmers avoided this region. At the time when more advanced farming

\* The figures 7, 9-12, 19, 21, 22 and 24 are added separately to this volume.

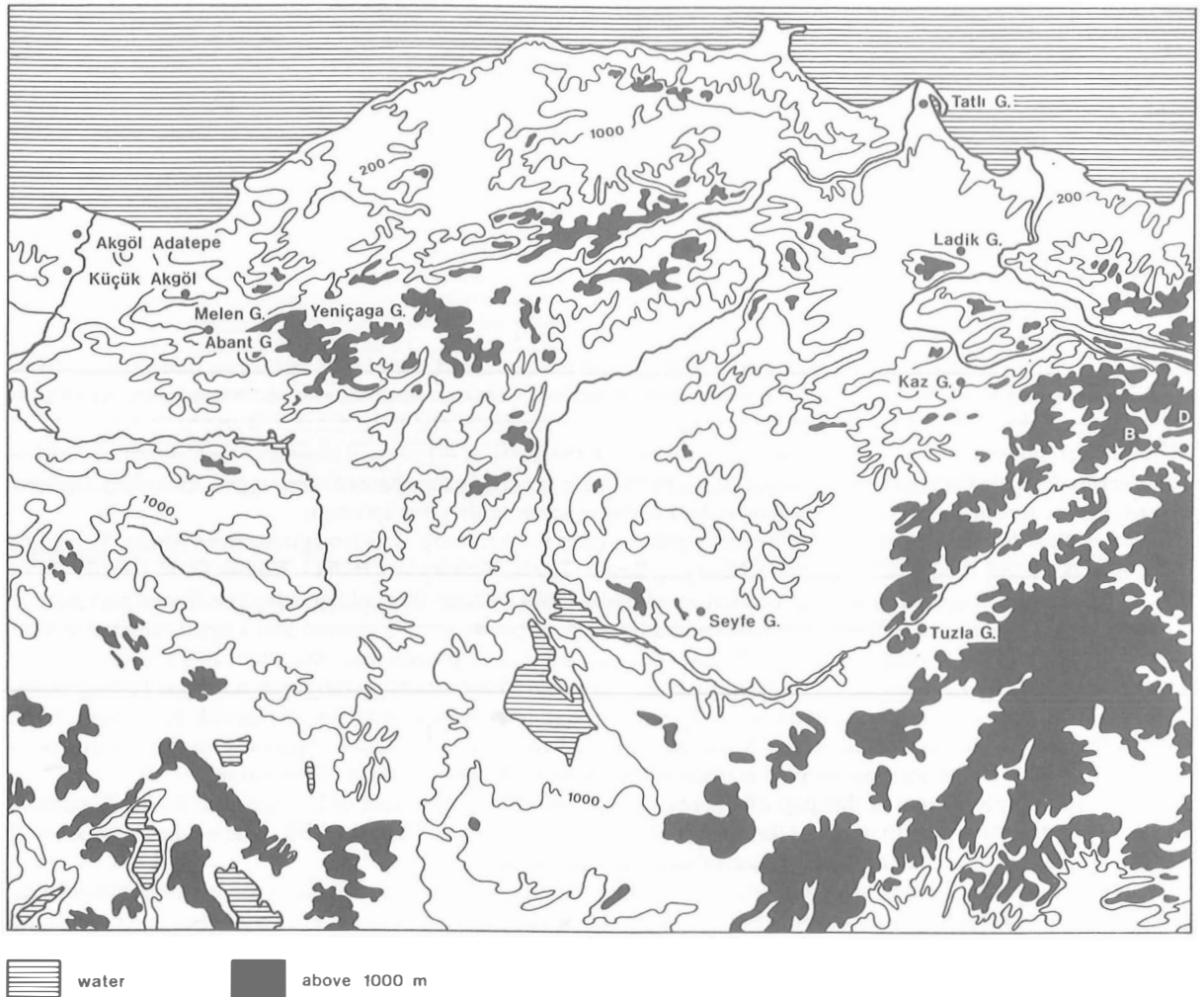


Fig. 1. Contour map. B: Büyük Gölü; D: Demiryurt Gölü.

spread towards open alluvial plains along the Mediterranean, small-scale habitation will have occurred in northern Turkey, where subsequently forest-exploiting prehistoric communities developed. Their structures contrast with the well-known mud-brick tradition of the Near East (Roodenberg, 1993). Such habitation demonstrates the adaptation to other environments, leading to the economic exploitation of new and rich resources. This study will present an outline of the environmental development of a part of Turkey where mankind has played an increasingly important role, but where up to modern times some parts have remained relatively untouched because they were beyond the technical and physical capacity of the people.

## 2. METHOD

Localities which came into consideration for further investigation were taken from maps (*Yeni Türkiye Atlasi*,

1977) kindly supplied by Dr. J.J. Roodenberg (Istanbul). The list of potential coring locations was screened and completed by Professor B. Aytug, who arranged permission from the authorities. Thirteen locations were sampled during the 1984 campaign (fig. 1).

Depending upon the presence of lakes or marshes, the aim was to sample along transects which covered variations in relief, climate and vegetation. Such a transect is the transition from the (salt)steppe to increasingly forested parts, from Tuzla Gölü towards Kaz Gölü and Lâdik Gölü and ending in Tatlı Gölü. A short transect, including very high elevations down to sea-level, comprises the locations of Abant Gölü, Melen Gölü, Küçük Akgöl and Adatepe. The fact that geographical transects of corings were investigated was no guarantee that the core records would cover the same periods. Some cores represent much shorter time records than others in the same transect.

The field work was done by the first two authors, together with Dr. W.H.E. Gremmen (Groningen) and

Mr. Ali Kılıç (Orman Fakültesi (Forestry Faculty) of the University of Istanbul). The Forestry Department offered board and lodging and in some instances transport facilities.

Depending on the local sediments, a Dachnowsky sampler of 25 cm chamber length and 3.6 cm diameter, a Dachnowsky-type sampler in combination with a Livingstone piston (capacity 35 cm chamber length, 3.6 cm diameter) or a Livingstone sampler with a capacity of 100 cm were used.

Each pollen diagram prepared for this study will be discussed separately. A more general discussion, in which the results are compared, will be given in section 9.

### 3. GEOGRAPHY

Most of the following information on the landscape is obtained from Erol (1983), Abdulsalam (1988) and Mayer & Aksoy (1986). The area treated in this study is bordered to the west by the Sakarya valley and the Adapazarı region, the stream valley of the Kızılırmak to the south and that of the Yeşilırmak and the inner eastern Taurus mountains to the east. To the north the area is bordered by the Black Sea.

The area can be divided into three main regions (fig. 1): 1. The lowlands bordering the Black Sea including the Sakarya valley; 2. The series of mountain chains which run roughly parallel to the Black Sea coast; 3. The Anatolian plain.

#### 3.1. The stream valley of the Sakarya

On the west side, the studied area is bordered by the Sakarya river which runs from the south towards the Black Sea (fig. 1). In the southern part of this stream valley the town of Adapazarı lies in a wide tectonic basin. North of this basin the Sakarya cuts through hills of up to 150 m high. The whole valley has a high water table and on both sides lakes are found in the hills, such as Küçük Akgöl. North of these hills the river has formed a wide valley with predominantly sandy deposits which are probably of young (Holocene) age.

Before the river discharges through a delta into the Black Sea, it flows through low hills where the lake of Akgöl-Adatepe is found. Further north, sand barriers have been formed by the interaction of the Black Sea and the Sakarya. Between the river and the sand barriers small lakes were formed. Because of the dynamic behaviour of the river, the age of such small lakes must be young.

The Sakarya river transports much water during the winter and spring, when large parts of the sandy valley are inundated. Swamp forest and forest growing under moist conditions (high ground-water level) are found on the eastern bank around Sölman Gölü.

#### 3.2. Mountain chains running parallel to the Black Sea coast

The western Black Sea region is dominated by mountain chains running in a WSW-ENE direction, whereas in the central part (Bafra-Farsa) the main direction turns to NNW-SSE. Through this part run the Kelkit, Yeşilırmak and Cekerek rivers.

The Pontic chain forms a continuously high wall which runs parallel to the Black Sea. The windward side of these mountain ranges is ruled by a moist climate typical of the area. The mountain ranges display a parallel series towards the interior, which is expressed in the climate by decreasing precipitation. The changes of the features from N to S and E to W made Erol (1983) divide the Black Sea region into a western, a central and an eastern subregion. The basis for this subdivision is the main direction of the mountain chains and their subsequent exposure and weather system.

The mountain chains in the western Pontus have an orientation perpendicular to the northerly, rain-carrying winds. Along the coast this results in climatically wet conditions and moderate temperatures. Towards the southeast a strong continental climatic impact is found because the mountains prevent further transport of moisture.

The orientation of the mountain ridges causes rainfall in wintertime when air from the west and southwest can easily penetrate. This creates favourable conditions for moisture-demanding forests in most of the area, though not on the southern slopes of the inner chains of the Köroğlu Dağları.

Between Zonguldak and Sinop, up to the area southwest of Bafra (figs 1 and 3), the Küre mountains (2019 m) rise, separated from more central ranges by wide plains. The Küre Dağları have a typical Black Sea climate, viz. moist and moderate throughout the year with cold air penetrating infrequently. On the sea coast, vegetations of the Mediterranean Colchic type are found. With increasing elevation, more and more cold-resistant, moisture-demanding forest is found. On south-facing slopes of the Küre mountains *Trockenwald* (Erol, 1983) is already present, indicating the first dry conditions.

Climatically the Küre mountains are quite different from the next chain, the Ilgaz Dağları, which has a rather dry climate, and where moisture-demanding forest is confined to some scarce spots.

East of Sinop the study area includes the deltas of the Kızılırmak and the Yeşilırmak rivers. These rivers form part of Erol's (1983) central Black Sea region where the main orientation of the inland mountain chains has changed towards NW-SE. The Canık Dağları (1100-1500 m) run parallel to the direction of the wintery wind but receives little precipitation. Because of the low altitude of the mountains, the influence of the sea is felt far inland.

The upper reaches of the Kızılırmak and the Yeşilırmak enclose an area lacking high mountain

chains like those which dominate the northern region. Still, the area is not uniform in character and several mountains and basin units are identified. In the north-east, relatively cool climatic conditions are met with, compared with the southwest which is drier and warmer. Here steppe and forested areas interfinger, mainly because the Pontic mountain ridges dip to the southwest under the Tertiary layers of central Anatolia. The mountains receive relatively much precipitation, but the winter temperature is low, which explains the occurrence of cold-resistant dry forests. In the warm and dry basins one may find the first steppe plants.

### 3.3. Central Anatolian plain

The central part of Anatolia includes the central and upper reaches of the Kızılırmak. The river springs from a high plateau of 1200-1400 m intersected by deep valleys. The river forms the so-called Halys around the Bozok Yayla where some mountains reach 1500-1700 m. Summers are dry and relatively cool, winters are very cold.

The lower part bears steppe vegetation and on the mountains dry forest is found. The western border is formed by Tuz Gölü and the Kızılırmak valley, the south and the east by the Taurus mountains.

The investigations extended to the upper reaches of the Kızılırmak east of Sivas and include the area of Hafik and Demiryurt. Here, the Kızılırmak river runs through a valley which has a dry climate, which is intensified by gypsum layers, which cause karstic phenomena. In the lower parts of the upper Kızılırmak river valley, steppe vegetation is met with, which on the high slopes is mixed with dry forest.

## 4. CLIMATE

In this section a general outline of the climate of the area will be given. More specific information will be provided in the description of the core locations. Various publications inform us on the climate of Turkey. Average monthly precipitation and temperature can be obtained from the 'New Turkish Atlas' (scale 1:800,000) (*Yeni Türkiye Atlası*, 1977) and the maps of the *Tübinger Atlas des Vorderen Orients* (TAVO) (scale 1:160,000 and 1:1,000,000) including A IV 1: Average annual temperatures (Alex, 1983a), A IV 2: Average January temperatures (Alex, 1983b), A IV 3: Average July temperatures (Alex, 1983c), A IV 4: Average annual precipitation and variability (Alex, 1984) and A IV 5: Precipitation probability (Alex, 1985). The maps of

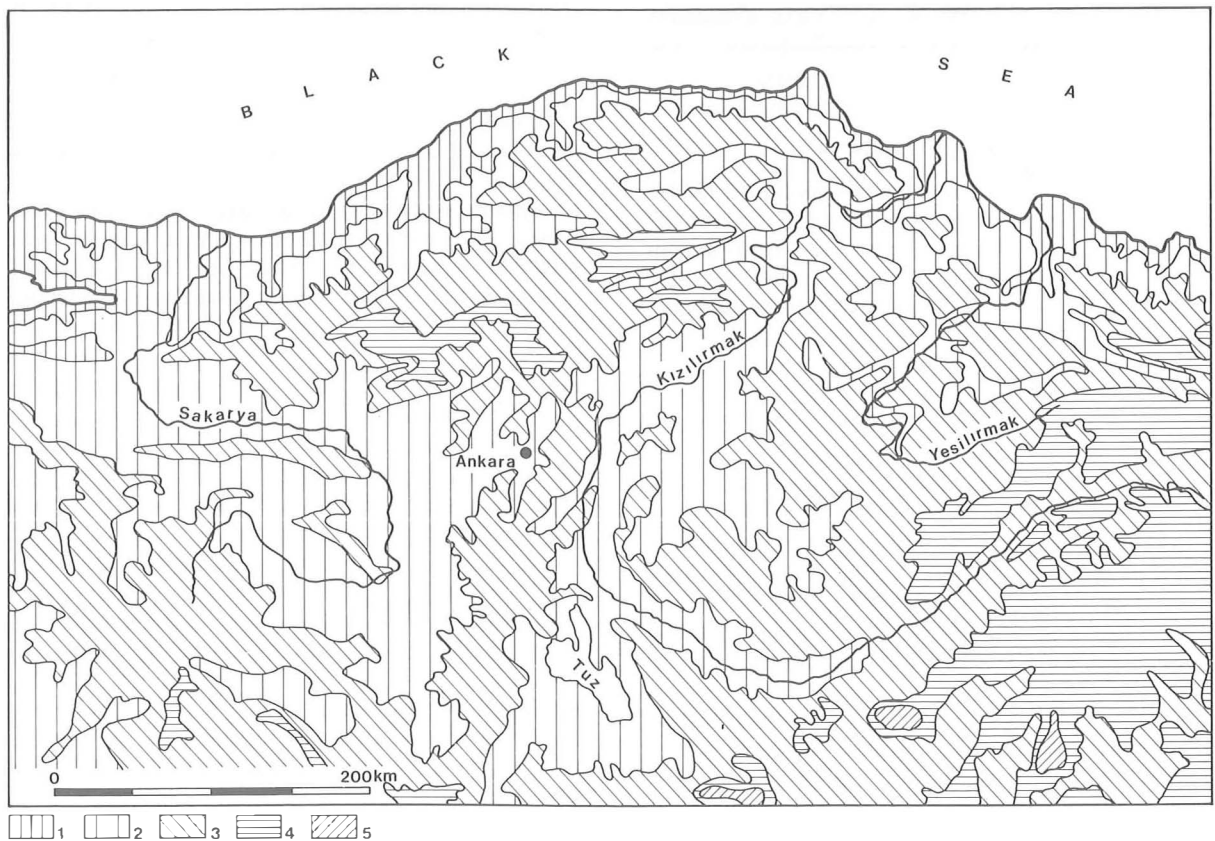


Fig. 2. Average January temperatures. 1: 4-0°C, 2: 8-4°C, 3: 0-(-4)°C, 4: -4-(-8)°C, 5: -8-(-12)°C.



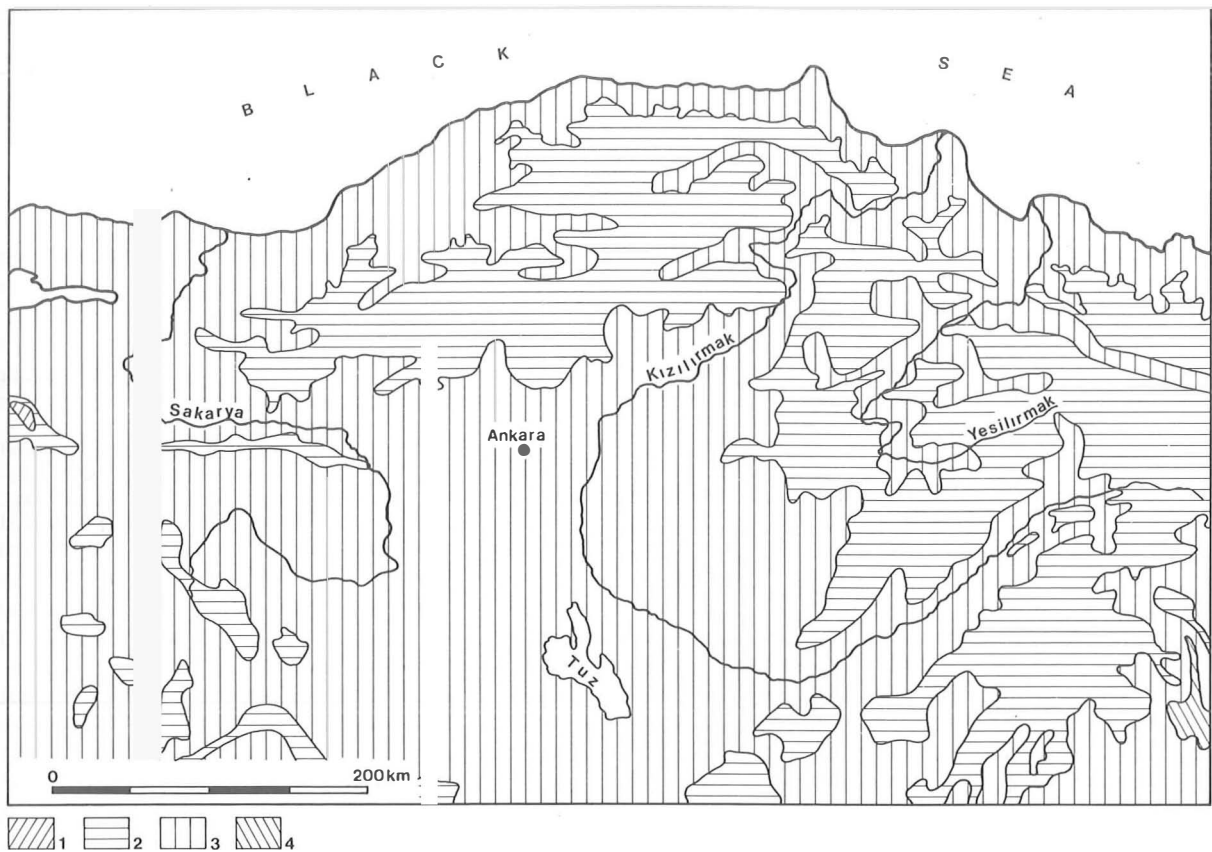


Fig. 3. Average July temperatures. 1: 12-16°C, 2: 16-20°C, 3: 20-24°C, 4: 24-28°C.

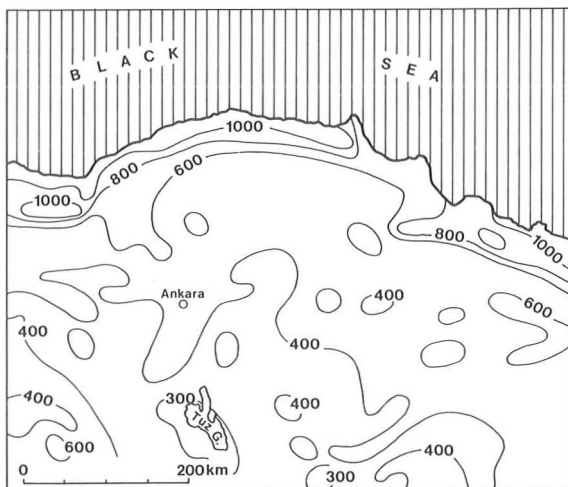


Fig. 4. Average annual precipitation.

figures 2, 3 and 4 are derived from the TAVO maps A IV 2 and 3.

The climate of Turkey in relation to the vegetation is discussed by Akman & Ketenoğlu (1986). Climate types connected with main vegetation types are given by Mayer & Aksoy (1986), from which the description

of the north-central Turkish climate is taken as a basis.

The wide variation in climate is explained by the orographical diversity. The east-west orientation of several rows of westerly mountain ridges near the Black Sea (see also 3.2), the deep valleys, the mountains towards the Anatolian steppe, the change in overall orientation of the mountains in the north-central plain, all these are responsible for the variation in climate. Turkey is often included in the Mediterranean area as well as the Near East, on the assumption that this country shares its climate with these regions. However, because of its considerable size various types or sub-types of the Mediterranean climate have to be recognized.

#### 4.1. The Euxinian belt

The prevailing climate of the northern mountain ridges is not a characteristic Mediterranean climate but a sea climate with a January temperature of 4-6°C and a July temperature of 21-24°C, under which regime the Euxinian beech forest flourishes. The temperature amplitude, the difference between the warmest and the coldest month, is 16-18°C.

The annual precipitation increases from west to east along the coast (700-1300 mm). Most of the rain falls during the autumn and winter. Average summer

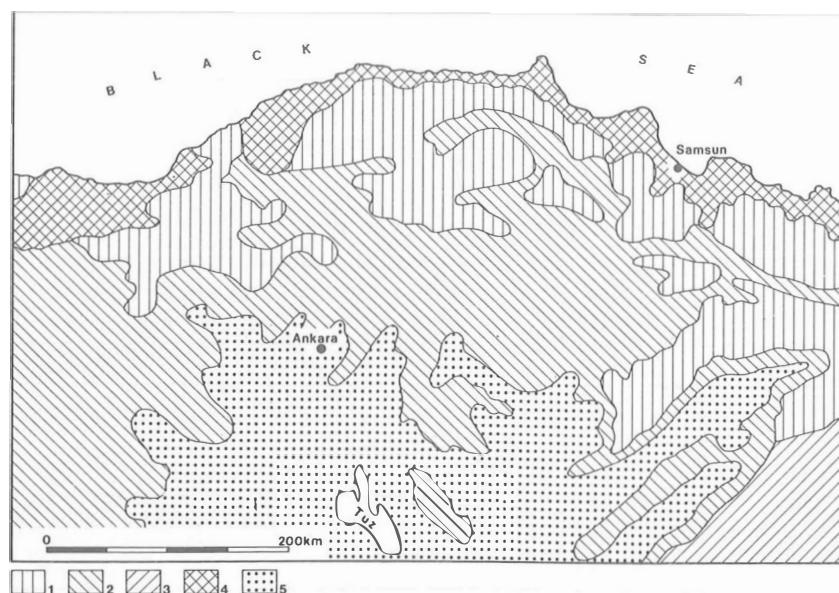


Fig. 5. Assumed natural vegetation of northern Turkey (after van Zeist & Bottema, 1991). 1. Montane forest; 2. Mixed broad-leaved and needle-leaved woodland resistant to cold; 3. Cold-deciduous broad-leaved montane woodland; 4. Cold-resistant deciduous forest; 5. Steppe.

precipitation is 100–250 mm, with summer temperatures of 20–23°C. According to Akman & Ketenöğlu (1986), the Kastamonu region has a non-Mediterranean climate with more precipitation during the summer (100–150 mm) than during the winter (80–100 mm).

#### 4.2. The sub-Euxinian belt

More inland the sub-Euxinian climatic belt forms the transition from the Euxinian seaclimate to the continental steppe climate of central Anatolia. Dryness in these parts is caused by the rain shadow of the mountains. The annual temperatures are 2–4°C lower than those along the Black Sea. This lowering is caused by the lower winter temperatures. Here the temperature amplitude is 18–21°C.

The precipitation (400–650 mm) has decreased to about half the amount which falls in the coastal region and falls mainly during the winter half year. For the summer, only 60–120 mm is reported, though summer temperatures are not very high. Differences from the coastal climate are more pronounced at lower (valley) levels than in the mountains.

The sub-Euxinian climate as described by Mayer & Aksoy (1986) does not completely match the subhumid climate described for the area by Akman & Ketenöğlu (1986), which covers a range of precipitation of 570–1100 mm.

#### 4.3. Central Anatolia

The continental climate of central Anatolia, i.e. the steppe forest climate of Mayer & Aksoy (1986) or the arid Mediterranean climate of Akman & Ketenöğlu (1986), is characterized by rather cold winters with average January temperatures ranging from +1° to –3°C.

The summers are quite hot, July marked by a temperature of 20–24°C. The part of central Anatolia between 900 and 1400 m, which is enclosed by the loop of the Kızılırmak (fig. 1), receives 240–400 mm of precipitation. In some valleys a summer precipitation of 30–40 mm is enough for tree growth.

### 5. THE MODERN VEGETATION

This section offers general information on the present vegetation (fig. 5). An attempt is made to form an idea of the potential vegetation, also in order to provide a basis of comparison with the subfossil record. To (re)construct the modern vegetation zones (fig. 5) for northern Turkey, a map is compiled on the basis of the map prepared by van Zeist & Bottema (1991). The latter is a schematic map compiled from the modern vegetation map of the Near East (Frey & Kürschner, 1989), the geobotanical map of the Middle East (Zohary, 1985), the *Carte de la végétation potentielle de la région méditerranéenne* (Quézel & Barbéro, 1985), a map of the area bordering Tuz Gölü (Kürschner, 1983) and information on the forest vegetation of Turkey (Mayer & Aksoy, 1986). The vegetation around the core locations is discussed as part of the site description (see 7).

During the coring expedition in 1984 notes on the vegetation were made with a view to studying the modern pollen precipitation (6.1). Special trips were made to gain an impression of the vegetation and forest cover. As the time for such exploration was limited, the main roads often had to be used and the team penetrated into the interior only near lakes and marshes. Although time and the aim of the coring project were restricting factors in this survey of the modern vegetation, a reasonable impression on the actual situation could be

obtained. Along the roads human impact was very strong. In most parts the vegetation, and especially the forest, has suffered very much. The forest has been destroyed nearly everywhere and even the herb vegetation is heavily affected by various forms of human exploitation. In some parts of the area severe erosion has taken place and barren substratum dominates the landscape. It will be clear that the construction of a potential natural vegetation map of such areas remains rather hypothetical.

The field notes on the modern vegetation, largely made in connection with the study of the modern pollen precipitation of northern and central Turkey (6.1), will be used if they offer additional information.

### 5.1. Description of the vegetation

Figure 5 gives an impression of the kinds of vegetation one may expect in the various zones of northern and central Turkey. These zones are marked with vegetation types, or species as reported by Quézel & Barbéro (1985) and Mayer & Aksoy (1986).

The following vegetation units (after van Zeist & Bottema, 1991) are simplified versions of those used in the map of the vegetation of the Middle East (Frey & Kürschner, 1989):

*Montane forests* (1). The inland montane forests vary to some extent because of differences in substratum as is also recorded on the soil map of the Middle East by Straub (1988). The soils include calcic cambisols, eutric cambisols, and haplic kastanozems. Characteristic species which immediately draw the attention are *Fagus orientalis* and *Abies nordmanniana*, which occur in smaller or larger numbers in the montane forest. Depending upon exposure, soil, etc., admixtures with other species or complete replacements can be found.

On southern exposures the montane forest may be formed by *Pinus sylvestris*, while in the undergrowth *Pyrola secunda*, *P. chlorantha*, *Moneses uniflora* and *Hieracium* occur.

In the Kastamonu area, from 33° to 35°E, beech and fir are postulated together with *Carpinus betulus*, *Quercus macranthera* and *Pinus nigra* as the natural vegetation.

In the mountains south of Sinop and Samsun the montane forest is typified by *Carpinus betulus*, *C. orientalis*, *Fagus orientalis*, various *Quercus* species, *Rhododendron flavum*, *Vaccinium arctostaphylos* and *Acer cappadocicum*.

The northern part of the high mountains, from the Sakarya river to Sinop, is covered by forest with *Fagus orientalis*, *Rhododendron ponticum*, *Rh. flavum*, *Carpinus betulus*, *C. orientalis*, *Castanea sativa*, various *Quercus* species, *Acer cappadocicum*, *A. trautvetteri*, *Hedera colchica*, *Daphne pontica* and *Crataegus pentagyna*.

The vegetations mentioned above start at sea level

and occur up to 1200 m on brown forest soils under a typical Euxinian climate with a precipitation between 1000 and 1500 mm annually without summer drought.

More inland the high mountains catch a variable amount of precipitation, often 700 mm and more, up to 1200 mm, with a dry summer period which lasts less than one month. Snow cover is 4 to 5 months. More to the interior, some parts may catch only 450-800 mm of precipitation combined with low temperatures.

On lime soils and volcanic deposits with a prolonged summer drought *Abies bornmuelleriana* grows at its limit, locally with *Pinus nigra*, various deciduous oaks, *Carpinus orientalis*, *C. betulus* and *Fagus orientalis*. For more details the reader is referred to Quézel & Barbéro (1985).

*Mixed broad-leaved and needle-leaved woodland resistant to cold* (2). Most of the zone south of the high mountain chains is covered by the Quercion anatolicae, a vegetation characterized by *Quercus pubescens* ssp. *anatolica*, *Pyrus elaeagnifolia*, *Colutea cicalica*, *Jasminum fruticans*, *Paliurus australis* and *Falcaria rivini*. The marginal forest and shrub are the result of the action of man, who could easily degrade the original woodland. Here and there small stands of *Pinus nigra* are found where precipitation ranges between 500 and 900 mm annually. Summer drought in this zone fluctuates between 3 and 6 months and snow cover persists 2 to 4 months during the winter.

*Cold-deciduous broad-leaved montane woodland* (3).

*Cold deciduous forests* (4). Where the coast rises from the sea, the vegetation is characterized by the so-called Crataego-Fagion, forests which include *Quercus macranthera*, *Q. iberica*, *Q. hartwissiana*, *Fagus orientalis*, *Carpinus orientalis* and *Carpinus betulus*. This type of forest extends from 0 to 500-700 m, on deep acid soils, often siliceous colluvium. Precipitation is more than 800 mm annually and the average minimum temperature of the coldest month is higher than 3°C.

Lowlands, bordering the Black Sea in the Sakarya delta, around Zonguldak, to the west and east of Inebolu, and around Sinop and Samsun, are covered by forest of *Quercus ilex*, *Pinus brutia*, *Laurus nobilis*, sometimes together with *Phillyrea media*, *Carpinus orientalis*, *Arbutus unedo* and *A. andrachne*. Where this is exploited by lumbering and/or grazing, *Erica arborea*, *Cistus creticus*, *C. salviaefolius*, *Myrtus communis* and *Juniperus oxycedrus* are mentioned by Quézel & Barbéro (1985). The climate is humid to sub-humid and locally even cold with a dry period of 2 to 4 months.

Under natural conditions the deltas of the Kızılırmak and the Yesilirmak would carry a riverine forest dominated by the Populetalia and characterized by *Alnus glutinosa* and *Fraxinus excelsior*. As a Pontic element *Pterocarya fraxinifolia* may have occurred in such surroundings. On wet alluvial soils, vines such as

*Periploca graeca*, *Smilax excelsa* and *Vitis vinifera* are present. The temperate Euxinian climate is marked by more than 900 mm annual precipitation, and the coldest month is above 3°C on average.

*Dwarf-shrub lands (steppe)* (5). This zone, which receives less than 400 mm of precipitation annually, is by origin very diverse in herb vegetation (Quézel & Barbéro, 1985), but extensive cereal farming has levelled this characteristic. Quézel & Barbéro mention vegetations with *Astragalus*, *Globularia*, *Onosma*, *Thymus*, *Salvia*, *Marrubium*, *Acantholimon*, *Onobrychis* and *Genista*. Furthermore a typical natural steppe vegetation with *Artemisia fragrans*, *Noaea mucronata* and *Thymus squarrosus* is mentioned (Zohary, 1973). Ploughing for crop farming and (over)grazing has affected the vegetation very much and a reconstruction of the potential plant cover is therefore difficult if not almost impossible. Where the mountains are high enough, woodland of *Quercion anatolicae* type is present or may have occurred. The climate of the steppe area is characterized by summer drought of 2 to 4 months and winter snow cover is very irregular, lasting 1 to 5 months (Quézel & Barbéro, 1985).

## 6. MODERN POLLEN PRECIPITATION

During the coring project in 1984 a series of surface samples were collected. Sampling of the present-day pollen precipitation is closely connected with the evaluation of the subfossil evidence. In the field, surface sampling was combined with the primary aim of the field work, the coring. This means that the surface samples come from areas that were visited in the first place for coring and which had to be reasonably

accessible. Time was the main restricting factor, and sampling was limited to a c. 500 m wide strip on either side of the road to enable transportation of the coring equipment (fig. 6). On some occasions a special excursion in the field was made to study the vegetation and to collect surface samples. A trip to the protected area Yedigöller (Seven Lakes), north of Bolu, deserves special mention.

The surface samples generally consist of moss cushions or pieces of moss cover. If otherwise, the origin of the sample (litter or soil) is given in the description. The numbers, locations, elevations and coordinates of the surface samples are given in table 1. The numbers of the surface samples refer to the sequence in which they were collected (fig. 6). The pollen counts are presented as a block diagram (fig. 7). The surface samples were classified according to the codes of the vegetation map by Frey & Kürschner (1989). The samples are presented in the order in which they were collected, starting with number one near Seyfe Gölü. The sample series proceeds from the steppe (1-6) through the forest-steppe (8-9) across the mountain chains and descends to the Black Sea (11-19) in the Kızılırmak delta. The second part, Nos 20-38, runs from the coastal area near Sinop to the high mountains near Abant through the valleys of the Göksu and the Araç. Samples 34 and 35 were collected along the lower reaches of the Sakarya river and 39 and 40 were collected in the eastern Taurus.

### 6.1. Surface sample description

#### *General zone: steppe*

1. Seyfe Gölü. Sample taken not far from the village of Gümüstümbet Köyü. Local vegetation cover c. 50%, including Geraniaceae, *Cerastium semidecandrum*,

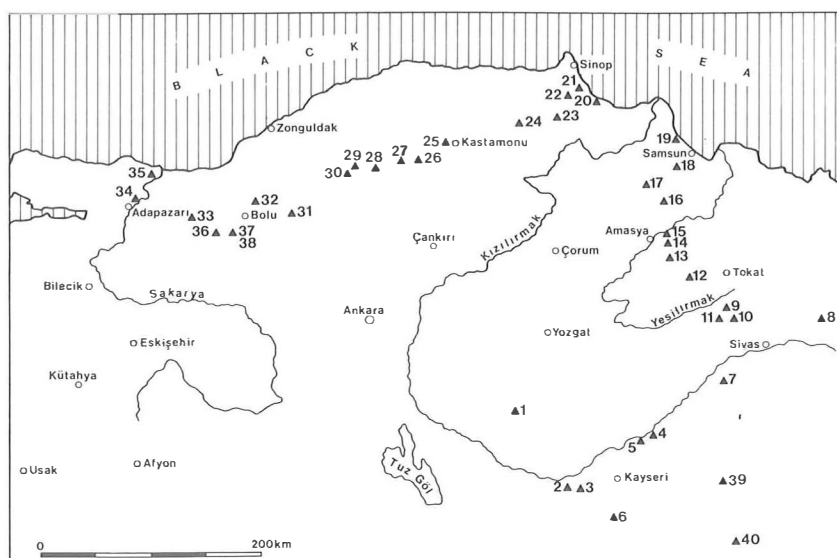


Fig. 6. The surface sample locations.

Table 1. Numbers, locations, elevations and coordinates of surface samples.

No	Location	Elevation in metres	Latitude N	Longitude E
01	Seyfe Gölü	1100	39.20 (39°12')	34.38 (34°22'36")
02	Göreme	1100	38.63 (38°38')	34.93 (34°56')
03	Basdere	1200	38.59 (38°35'30")	35.03 (35°01'30")
04	Tuzla Gölü (N)	900	39.03 (39°02')	35.79 (35°47'30")
05	Tuzla Gölü (W) (Çavlak)	900	39.07 (39°04')	35.83 (35°50')
06	Sultansazlığı	1000	38.28 (38°17')	35.38 (35°23')
07	Elmalı	1200	39.40 (39°24')	36.47 (36°28')
08	Demiryurt Gölü	1200	39.88 (39°53')	37.61 (37°36'30")
09	İlica I	1400	39.95 (39°57')	36.53 (36°31'30")
10	İlica II	1400	39.95 (39°57')	36.53 (36°31'30")
11	İhsaniye	1200	40.02 (40°01')	36.50 (36°30')
12	Kaz Gölü	500	40.27 (40°16')	36.15 (36°09')
13	Turhal	450	40.42 (40°25'12")	36.09 (36°05'30")
14	Diphanman	600	40.48 (40°29')	36.15 (36°09')
15	Şeyhşadi	700	40.53 (40°31'30")	36.16 (36°09'30")
16	Lâdik Gölü	800	40.90 (40°54')	36.02 (36°01')
17	Havza	750	40.98 (40°59')	35.72 (35°43')
18	Çaklı	750	41.17 (41°10')	36.13 (36°07'30")
19	Çam Gölü (Çavuş)	50	41.38 (41°23')	36.21 (36°12'30")
20	Carnıyanı	200	41.73 (41°43'30")	35.25 (35°15')
21	Gerze	75	41.82 (41°49')	35.18 (35°11')
22	Tangal	1300	41.81 (41°48'30")	35.03 (35°02')
23	Karandi	1300	41.63 (41°37'30")	34.85 (34°51')
24	Yukarıseki	550	41.57 (41°34')	34.28 (34°17')
25	Kavakköy	1000	41.37 (41°22')	33.32 (33°19')
26	Araç	800	41.25 (41°15')	33.67 (33°40')
27	İğdir	500	41.15 (41°09')	33.22 (33°13')
28	Kadıbükkü	350	41.20 (41°12')	32.87 (32°52')
29	Karıt	300	41.23 (41°13'30")	32.72 (32°43')
30	Çerçiler	250	41.18 (41°10'30")	32.63 (32°38')
31	Yeniçağa Gölü	980	40.78 (40°46'30")	32.01 (32°00'30")
32	Yedigöller	1200	40.85 (40°51')	31.62 (31°37')
33	Melen Gölü	125	40.78 (40°46'30")	31.10 (31°06')
34	Küçük Akgöl	50	40.87 (40°52'24")	30.44 (30°26'30")
35	Akgöl Adatepe	50	41.03 (41°02')	30.57 (30°34')
36	Sülük	1650	40.58 (40°35')	31.25 (31°15')
37	Abant Gölü I	1300	40.61 (40°36'24")	31.30 (31°18')
38	Abant Gölü II	1375	40.61 (40°36'24")	31.31 (31°18'30")
39	Bahçe			
40	Göksun			

*Senecio*. At c. 1 km distance *Salix* and *Populus*.

From Kırşehir via Göreme to Kayseri, at first young pine plantations with *Cornus*, finally barren land. Beyond Ürgüp, c. 10 year old *Quercus cf. pedunculata*.

2. 10 km east of Göreme, beyond Ürgüp, two patches of degraded oak scrub on slope. In valley *Amygdalus*, *Populus* and *Salix*. Much grazing and small terraced fields with *Triticum durum*.

3. Near Başdere, east of Ürgüp.

4. At the north bank of Tuzla Gölü. Treeless area.

5. On the west side of Tuzla Gölü near Çavlak. Treeless area.

6. In the Sultansazlığı along a dirt track from the east, starting at Karacaören. The track had been cut by a stream discharging from the southern mountains into the flats. To the north, a shallow lake and mud flats, to the south a grazed steppic area, almost devoid of vegetation.

*General zone: steppe forest*

7. At the side of the road from Kayseri to Sivas, c. 65 km before Sivas and c. 10 km before Şalluşhe. Near a field with a lentil crop.

8. At the southern shore of Demiryurt Gölü. Lake fringed with *Phragmites australis* and *Scirpus lacustris*. Flats south of the lake were overgrown with Cruciferae.

*General zone: montane forest*

9. 57 km by road from Sivas to Tokat. Northwest-facing chalk slope at 1200 m altitude with *Pinus nigra* and *Juniperus*. Litter from various localities along slope. Vegetation: *Muscari*, *Centaurea*.

10. Moss from the same locality as sample 9.

11. In Çamlıbeli Dağları, north of the pass, 69 km by road from Sivas to Tokat, between 1300 and 1600 m altitude. Deciduous *Quercus* shrubs and *Pinus*, possibly planted.

*General zone: steppe forest/montane forest*

12. South of Kaz Gölü. Sample taken from moss on a stone along the main road, because near the coring locality no moss could be found. Arable land changing into marsh land towards the lake. Grazing. Far away on southern mountains, trees or forest visible. Locally Cruciferae and *Euphorbia*.

13. 1 km north of Turhal. Bare slopes with patches of *Paliurus spina-christi*. Valley densely covered by *Populus*. West and south slopes show much *Juniperus excelsa*. East-facing slope is barren. Along the road *Fraxinus*. Local vegetation on gravel. Sparse cover with *Euphorbia*, various Gramineae, *Artemisia*, *Eryngium*, *Scleranthus*, Labiatae, Caryophyllaceae, *Verbascum*, cf. *Senecio*. At a higher elevation, *Peganum harmala* and *Paliurus*.

14. Some kilometres north of sample 13. West-facing slope with fairly dense *Juniperus oxycedrus*; further *Phillyrea*, *Paliurus*, *Onosma*, *Pedicularis*, *Myosotis*, yellow-flowering Compositae, various Gramineae. After a few kilometres *Quercus* is found with some *Pistacia* scrub. At a higher elevation, *Pinus nigra* and finally low oak scrub and some large oaks. Where the road descends, arable land is found with some large oaks.

*General zone: montane forest*

15. Pass between Buzluk and Sakarat Dağları, not far from Şeyhsadi, with *Pinus nigra*. At a lower elevation, various oak species. Sample from two rock localities. Shrubby *Crataegus* and *Quercus infectoria*. Abundant *Myosotis*; further *Onosma*, cf. *Astragalus*, Gramineae, Cruciferae, Papaveraceae, *Lathyrus sativa*, *Muscari*, *Rosa*, various Leguminosae.

16. SE of Lâdik Gölü. Valley between Amasya and Lâdik mostly cultivated; trees are mainly planted poplar and fruit trees. At 15 km by road near Uzunoba a small mountain road was taken via Ahören to Lâdik. This road was difficult to negotiate and passed through forest. To Lâdik Gölü and Erboşa at a barrage across the Borraçay (900 m). Most of the forest seen during the trip is between 600 and 900 m. The lower part, dependent on exposure and soil, is covered by *Carpinus betulus*. Most of the forest is regenerating from shoots after cutting and not older than 20 years. The landscape seems to be maintained by local farmers in a cutting and grazing system. At a higher elevation in the *Pinus/Quercus* forest, flowering *Crataegus* is found. On higher parts of the Karaömer Dağları some snow and alpine meadow can be seen (22th May 1984). At about 900 m *Quercus cerris* and *Q. infectoria* were identified.

17. 10 km north of Havza, near small village of Yenice. Cultivated area, rare solitary deciduous oak. At several kilometres' distance a mountain slope with deciduous forest.

18. 35 km by road south of Samsun. Dense regenerating forest: three *Quercus* species, abundant *Carpinus orientalis*, *Cornus mas*, a few *Acer* cf.

*monspessulanum*, *Crataegus*, *Phillyrea*, *Hedera*. Herbs include *Helianthemum*, *Centaurea*, *Polygala*, *Carex*, *Cerastium*, *Geranium*, *Veronica*, *Bellis perennis*, *Scrophularia*, *Helleborus*, Umbelliferae, *Globularia*, *Trifolium*, *Onosma*, *Poa viviparum*, *Matricaria*, *Primula*, *Galium*, cf. *Asparagus*, *Salvia*, *Luzula*, *Ranunculus*, *Cistus*, *Ornithogalum*.

*General zone: cold deciduous lowland forest*

19. Steep slope descending into the Black Sea. Local name 'Çam Gölü' means 'pine lake'. This points to the large number of Austrian pine, there is no 'Gölü' (lake). The slope is densely covered with *Pinus nigra*. Also *Carpinus betulus*, *Pistacia terebinthus*, *Erica arborea*, abundant *Laurus nobilis* and *Arbutus*. Up the slope, along the track: *Spartium junceum*, *Quercus cerris*, *Q. pedunculata*, unidentified *Quercus*, *Juniperus* cf. *oxycedrus*, *Cistus* spec. (large pink flower), *Phillyrea*, *Prunus*, *Ruscus aculeatus*, *Tamus*, *Smilax*, *Clematis* (two species), *Platanus*, *Carpinus orientalis*, *Vitis sylvestris*, and abundant *Hedera helix* climbing up *Pinus nigra*.

20. Roadside before Gerze, on the road from Çam Gölü to Sinop. Locally: *Pulicaria*, *Trifolium*, *Lotus*, various other Leguminosae, *Bromus*, cf. *Onosma*, *Centaurea* cf. *calcytrapa*, *Bellis perennis*, *Sisymbrium*, *Trifolium* cf. *resupinatum*, *Carduus*, *Olea*. Further away: *Rumex*, *Rubus*, *Anagallis*, *Rosa*, *Trifolium* cf. *dubium*, Umbelliferae, *Ophrys*, *Geranium*, *Plantago*, *Adonis*, *Spartium*. On distant slopes forest can be seen.

Between sampling point and Gerze on the road to Sinop: *Colutea arborescens*, *Cotinus coggygria*, *Quercus cerris*, *Q. pedunculata* on yellow loamy clay. Around houses plantations of hazel; near Gerze many olive trees. Beyond Gerze to the interior, a landscape of low hills with less and less forest, but ever more farmland. At some distance *Quercus pedunculata* forest is bordered by *Psoralea bituminosa*. Near the road occasional oak forest on east-facing slopes. On west-facing slopes down to the valley extensive forest of *Pinus nigra* and *Abies nordmanniana*.

21. Near Altinyayla junction. Sample from under *Tussilago*.

*General zone: mixed broad-leaved woodland resistant to cold*

22. Near Soğuksu. Grazed forest of *Fagus orientalis*, *Abies nordmanniana* and *Pinus* cf. *sylvestris*. The effect of erosion is visible on the mountain meadows. The sample was taken in a grazed area; *Plantago lanceolata*, Leguminosae, Gramineae, Compositae.

Below the pass some beeches. *Pinus sylvestris* replaces beech 2 km southward. More towards the valley floor, grazed oak forest. Finally, in the valley, grazed and eroded landscape with cf. *Berberis*.

*General zone: montane forest*

23. Near Karandi. Sample on rock outcrop along the

road. Grain fields with solitary oaks. At some distance, forest of deciduous trees and pine. Occasionally fruit trees, planted or wild. Sampling site with *Quercus* and *Berberis* cf. *vulgare*, *Viola* (abundant) and *Leguminosae*. Travelling towards Çuhali *Juniperus* appears, finally the landscape turns barren with sparse *Berberis*.

24. Sample from bare, eroded landscape. Some *Juniperus* or *Berberis*. After crossing the Gökırmak, mainly *Pinus nigra* forest, later replaced by *Juniperus excelsa* along the slopes. Towards Taşköprü oak forest becomes important. From Taşköprü to Kastamonu the valley of the Gökırmak is mostly cultivated. After Kastamonu degraded oak/pine forest with *Juniperus* and *Berberis*. 16 km west of Kastamonu first *Abies nordmanniana* and *Populus tremula* appears.

25. Sample collected in oak scrub (*Quercus pendunculata*) with some *Pinus nigra* and *P. sylvestris*. On north slopes conifers can be seen. Locally *Cotinus*, *Juniperus* cf. *oxycedrus*, *Helianthemum*, scrubby *Ericaceae* (sometimes dominant), *Corylus* (rare).

26. Some 65 km by road west of Kastamonu. Predominantly *Pinus nigra*, with *Quercus* in lower stratum. River valley with many *Tamarix*, *Berberis*, *Rubus* and a few *Quercus*.

*General zone: mixed broad-leaved and needle-leaved woodland resistant to cold*

27. Near İğdir. Sample collected especially for studying the representation of *Juglans* in the pollen rain. Cultivated land with some *Juglans* trees along 20 m of roadside. Farther away another ten walnut trees about 100 m apart. At 100 m distance an oak/pine stand near a beet field. Next 10 km: fields, now and then *Juniperus* cf. *excelsa* and oak. On the mountain crest *Pinus* cf. *nigra*.

28. Sample 200 m from *Juniperus* vegetation. Locally *Berberis* and rich herb cover. In ravine *Quercus*. *Pistacia terebinthus* in fruit is fairly common.

29. Near Karabük, where a soft stone formation is present with some *Berberis*. Sample taken to measure the pollen value of *Pistacia*. Ten km to the west, in a marshy area near the village lies an uninhabited tell. Increasingly sparse vegetation on quite clayey soil.

*General zone: mixed broad-leaved and needle-leaved woodland resistant to cold/montane forest*

30. Sample taken c. 5 km west of Karabük. *Juniperus excelsa* is the main species. *Pinus nigra* is seen at some distance. Locally, near the sample, *Juniperus*, *Paliurus*, *Berberis*, *Rubus*, *Boraginaceae*, *Plantago lanceolata*. Ten km from Karabük a grazed area with fields and some fruit trees. Far away, forest can be seen. Locally an oak stand is present.

31. Sample collected at the shore of Yeniçağa Gölü in the marsh. Local cover mainly flowering cf. *Blysmus*. About 20 km east of Bolu pines grow on the crest of the mountains. Oaks and possibly hornbeam are found on the slopes.

*General zone: montane forest*

32. Sample taken in Yedigöller Nature Reserve. North of Bolu extensive forests of *Abies nordmanniana* and *Fagus orientalis* are found. At lower elevations various types of deciduous vegetation, especially on the river banks.

*General zone: cold deciduous lowland forest*

33. At the south shore of Melen Gölü. On the north-facing slope hazel plantations, alternating with stands of *Castanea sativa* and *Tilia argentea*. Near sampling locality *Sambucus ebulus*, *Pteridium*, abundant *Euphorbia*, *Rubus*, *Centaurea* cf. *calcitrapa*. *Trifolium resupinatum*, *T. repens*, *Bellis*, *Helleborus* cf. *orientalis*, *Urtica dioica*, *Smilax*, *Rumex*, *Bromus*, *Myosotis*, cf. *Mentha*, *Veronica* cf. *persica*, *V. fruticans*, *Alnus*, *Potentilla*.

34. Küçük Akgöl, north of Adapazarı. In the area mainly *Quercus* (two species), furthermore *Phillyrea*, *Cornus mas* (quite common), *Fraxinus excelsior*, *Rubus*, *Populus* and *Salix* were found growing on the shore of the lake.

35. Akgöl Adatepe. Sample taken from roadside with *Trifolium*, *Plantago*, *Compositae*, *Euphorbia*, *Rubus*. At 150 m from sample locality *Populus*, *Salix* and *Fraxinus excelsior* had been planted.

*General zone: montane forest*

36. Natural barrage of Sütlük. Sample collected from two stumps of drowned trees in the centre of the lake. Elevation c. 1600 m. Forest mostly *Pinus*, but here and there large *Taxus* and *Corylus*.

37. Abant Gölü. Sample collected in the marsh among various *Carex* species, including *Carex nigra*, *C. cf. diandra*, *C. paniculata*, *C. cf. hostiana*, *C. panicea*. Also found locally: *Gomarum palustre*, *Equisetum* cf. *palustre*, *Rubiaceae*, *Ajuga reptans*, *Orchis* spec., various *Umbelliferae*, cf. *Sonchus*, *Hypericum* spec., *Filipendula* cf. *vulgaris*, some *Salix* shrub. A little (150 m) south of the coring and sample locality *Abies nordmanniana* on a north-facing slope. A south-facing slope bears *Pinus sylvestris*.

38. Abant Gölü, about 100 m south of the lake at the crest of the mountains. Here and there *Abies nordmanniana* and *Pinus sylvestris* in open forest where grazing occurs. For a description of the vegetation, see Özhatay, 1986.

*General zone: cold-deciduous woodland*

39. Near Bahçe. Sample taken in vegetation of *Quercus castaneifolia* and other oak species (sampled by H. Woldring in 1988).

*General zone: cold-resistant needle-leaved forest*

40. Southeastern Taurus, pass near Kaksun, at 1600 m. *Quercus*, *Pinus* and *Juniperus* (sampled by H. Woldring in 1988).



## 6.2. Discussion of the surface samples (fig. 7)

Earlier studies on the relation of the present pollen precipitation to the vegetation of the Eastern Mediterranean and the Near East (van Zeist & Bottema, 1991) inform us about the behaviour of plant and tree species or vegetations in general, in terms of pollen percentages. In the present study such research was done to give information on northern Turkey especially. Spectrum 27 was specifically sampled to study the behaviour of *Juglans* pollen. In a treeless, cultivated landscape near İğdir five massive walnut trees stood along the road and at about 100 m another ten trees could be seen. Spectrum 27 gives 1.2% *Juglans* pollen. Spectrum 13 contains about 2% *Juglans*. This sample was also collected in an area almost devoid of trees apart from some *Paliurus* and *Juniperus* scrub. No walnut trees were observed in the field. A low percentage of walnut pollen is present in almost every sample whether there are trees or not. *Juglans* must have a good distribution, whereas it does not seem to precipitate very much locally.

The representation of *Pistacia* is somewhat puzzling as only 0.4% pollen of this small tree was found in spectrum 29. The sample was collected purposely for the representation of *Pistacia terebinthus*, which was very common locally; but its share is less than in samples where only a few Terebints were observed.

The general trends within the pollen spectra analyzed for the various landscapes in connection with the vegetation found, are of interest for the light they may shed on the subfossil spectra.

Low arboreal values are found for the samples of the steppe and steppe-forest (spectra 1-8) as could be expected. In cases where oak scrub, remnant of oak forest, is found in the area, oak pollen values can be remarkably high. Thus in spectrum 2 about 65% *Quercus* is present. Pine pollen averages 30%, being transported to the steppe with very small numbers of other tree pollen originating further away. Chenopodiaceae are important but they fluctuate strongly, having their highest values on barren lake shores where they are among the scarce species that can survive saline conditions. In these samples from open surroundings *Artemisia* is fairly well represented. It is surprising that the steppe zone has low *Plantago lanceolata* values where one would expect high plantain scores because of omnipresent grazing. Gramineae have c. 15% on average and they maintain these values from central Anatolia up to the Lâdik area (spectrum 17). Grass pollen values drop to about 5% in the east-west transect from Samsun to Karabük (spectra 18-30).

The contents of samples derived from the steppe do not differ notably from those of the steppe forest. The appearance of some trees in the open vegetation has no effect, compared with the overall level of transport into treeless areas.

The montane zone is characterized by high *Pinus*

values. *Pinus nigra* is seldom the only tree or even the dominant species but its pollen is fairly evenly distributed. High *Pinus* values are also found in the coastal zone (spectrum 19) where *Pinus nigra* dominates the forest. This part is described on the TAVO A VI 4 map (Frey & Kürschner, 1989) as 'Cold Deciduous Lowland Forest'. Many species of this forest zone were indeed observed during our visit to the area but at the same time Mediterranean elements were seen. All these species present in Çamgöl are greatly outnumbered by the pines and consequently the zone has to be described as a mixture of needle-leaved and deciduous and evergreen lowland forest.

In some samples from the montane forest *Juniperus* reaches 30-40%. In the remaining spectra only a few percent are found. The presence of reasonably developed *Juniperus excelsa* or *J. oxycedrus* trees is no guarantee that large amounts of juniper pollen will be found. On some occasions there is a relation of *Juniperus* trees/scrub to its pollen content (spectrum 14), sometimes there is hardly a relation (spectrum 24), sometimes there seems to be no relation (spectrum 29). Other types that characterize the montane zone, both in the vegetation itself and in the pollen precipitation, are *Abies* (5-10%), *Fagus* (3-6%) and *Carpinus betulus* (1-12%).

In those parts that are not classified as montane forest but as mixed broad-leaved and needle-leaved woodland, other characteristics are present. In fact these sampling localities do not carry the vegetation described for the classification. Invariably they are instead deforested, cleared, degraded, eroded, overgrazed or cultivated, as is often the case in the montane zone. It is only the potential vegetation that is mapped. The samples have been collected in situations that have 'disturbance' in common. Sometimes the disturbance is mainly cultivation, sometimes grazing is more important, often the road is a form of disturbance in itself. The spectra of the mixed broad-leaved and needle-leaved woodland demonstrate lower AP values than those of the montane forest zone. This is caused mainly by lower pine pollen values. Furthermore they are marked by an important share of *Plantago lanceolata* (10-60%). Grasses are more important in the lower zone, the coastal area of the Sakarya district. Pollen of *Olea*, *Platanus* and *Ulmus* is regularly met with. In the case of hazel plantations (spectrum 35) a reasonable amount of *Corylus* pollen is found.

Spectra 39 and 40 are situated somewhat outside the area and represent the higher part of the eastern Taurus. Here the influence of Mediterranean elements is felt, for instance *Quercus coccifera*-type, *Olea* and *Phillyrea*.

## 7. THE POLLEN CORES

### 7.1. Introduction

The palynological information, the 'raw counts', were

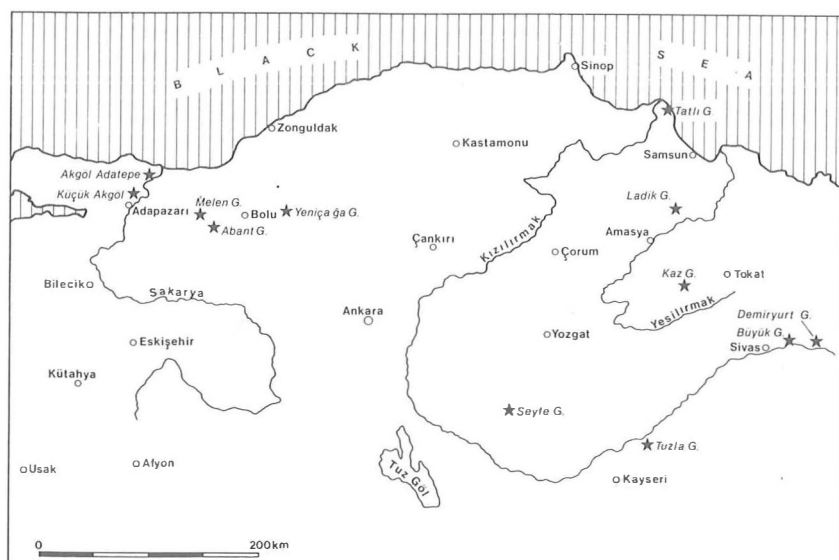


Fig. 8. Map of northern Turkey with the coring locations indicated by asterisks.

stored in a personal computer by means of a menu-directed programme called 'Grappa', which was prepared by the Rekencentrum (Computercentre) of the University of Groningen. This specially designed programme has a maximum registration capacity of 999 pollen/spore types per spectrum and 200 samples per core. For each spectrum maximally 9999 grains can be processed. The drawing of the diagram was effected at the Rekencentrum where a VAX 8650 delivered the final information to a HP Draftmaster II plotter. The layout of the drawing is ruled by 60 parameters.

The drawings provide the curves of the relative percentages of each pollen/spore type, calculated upon a pollen sum which in our study contains all types representative for the upland vegetation. Thus, local types, i.e. marsh and waterplants, are in general excluded from the sum. Undoubtedly some pollen types which cover a large taxonomical group may represent more habitats. The inclusions or exclusions from the pollen sum may sometimes be rather arbitrary. For a discussion of this problem the reader is referred to van Zeist et al. (1975).

To facilitate the evaluation, the pollen diagrams have been divided into zones. All pollen zones are numbered according to the same code, starting with the lowest zone as 1, the next one up as 2, etc. If necessary, a subdivision is marked with letters a, b, c, etc. It is emphasized that the numbering system merely serves to aid the discussion of the pollen record. The coding system is not meant for correlation. If zones in different diagrams with identical codes do correlate, this is a coincidence.

## 7.2. Abant Gölü (figs 8 and 9)

### 7.2.1. Geography

Abant Gölü (40° 36'N, 31° 17'E) lies c. 30 km southwest of the town of Bolu at an elevation of 1300 m (1298 m according to Beug, 1967) in the Abant Dağları. The highest peak in this mountain range measures 1585 m. The parallel Köroğlu mountain ridges reach 1800-2400 m at most (*Yeni Türkiye Atlası*, 1977). According to Özhatay (1986) the Abant mountains display high and steep slopes in all directions, except in the north, where they are lower. According to this author the Abant Tepesi in the southeast reaches 1700 m.

The lake covers about 125 ha and may have been formed by tectonics which caused a landslide. At present there is an outlet in the northeast.

### 7.2.2. Climate

The nearest weather station is that of Bolu, about 35 km east of the lake and at an elevation of 750 m. If the information of TAVO (Alex, 1983a,b,c) is used, the difference in altitude of the meteorological station and the lake has to be taken into account.

The area receives a precipitation of 500-600 mm. Average temperatures in January and July are in the range of -5 to -10°C and 15-20°C, respectively. Mayer & Aksoy (1986) describe the climate in vegetational units, and the area under discussion can be labelled Euxinian or sub-Euxinian. This would imply an average January temperature of -1 to -6°C and an average July temperature of 16-21°C. It is not clear whether discrepancies which are thus found are caused by the differences in altitude. During visits to Abant in 1984 and 1986 we were told by employees of the State

Forestry that winters had a long and heavy snow cover. As usual, microclimatic differences between north- and south-facing slopes can be very important, as is emphasized in Mayer & Aksoy (1986: p. 62, fig. 25 and p. 96, fig. 34).

### 7.2.3. Present vegetation

General information on the vegetation can be obtained from Davis (1965-1985), Atalay (1983), and Mayer & Aksoy (1986). For Abant Gölü a list of vascular plants is available (Özhatay, 1986). According to Mayer & Aksoy (1986) almost pure semi-humid fir forest (*Abies nordmanniana* ssp. *bornmuelleriana*) is found between 900-2000 m, with optimal growth between 1300-1600 m on the shadow (NNE) side of the mountains. Sporadically *Fagus orientalis*, *Pinus nigra* or *P. sylvestris* are met with. On the dry and sunny south slopes pine forest (mostly *Pinus sylvestris*) dominates. On the grazed mountainside west of Abant Gölü, we observed scattered *Pinus sylvestris* and *Crataegus*.

Özhatay's (1986) list of vascular plant species, which have been identified by many botanists on various field trips to Abant, will be used in the section on the discussion of the pollen diagrams (7.3.8). Here follows a selection of tree species: *Juniperus communis*, *Abies nordmanniana* ssp. *bornmuelleriana*, *Pinus sylvestris*, *Taxus baccata*, *Acer platanoides*, *Carpinus betulus*, *Fagus orientalis*, *Quercus robur*, *Q. virgiliana*, *Populus tremula* and six *Salix* species.

There are marshes on the western lake shore and in the southeastern corner of the lake there is quite a large peat bog. During our field work six *Carex* species were observed in the latter area. In the Optima excursion guide (Özhatay, 1986) the following *Carex* species are mentioned: *Carex acuta*, *C. distans*, *C. divulsa* ssp. *leersii*, *C. flacca* ssp. *serrulata*, *C. hirta*, *C. otrubae*, *C. panicea* and *C. tomentosa*. In the bog a few willow shrubs, *Menyanthes trifoliata*, *Comarum palustre*, *Equisetum* cf. *palustre*, Rubiaceae, *Ajuga reptans* and *Orchis* spec. were found. Towards the slope, under drier conditions, *Ranunculus* aff. *acer*, *Cardamine* cf. *amara*, *Epilobium*, various Umbelliferae, cf. *Sonchus*, *Hypericum* and *Filipendula* cf. *vulgaris* were encountered.

### 7.2.4. The coring

The sediments around Abant Gölü differ in composition. On the west side, hard clays with intercalating gravel layers are found under a vegetation of *Phragmites australis*. Coring turned out to be impossible here. On the southeast side, the peat bog was cored in alternating holes (see also Beug, 1967) up to 1045 cm. From this depth onward coring was done in one hole.

### 7.2.5. Lithology

60-140 cm	peat, hardly decomposed
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140-185 cm	a little more decomposed peat
185-211 cm	less decomposed peat
211-222 cm	clay
222-225 cm	peat, hardly decomposed
225-317 cm	peaty clay
317-443 cm	moderately decomposed peat
443-465 cm	clay
465-625 cm	peat; at 580 cm wood: possibly <i>Alnus</i>
625-725 cm	coarse peat ( <i>Typha</i> ?) or coarse peaty gyttja
725-800 cm	carr (wood peat)
800-955 cm	moderately decomposed peat, changing into gyttja
955-960 cm	clayey peat
960-1000 cm	peat with roots ( <i>Phragmites</i> ?)
1000-1045 cm	clay turning blue in the lowest part
1045-1105 cm	blue to blue-green clay with pieces of marl; the lower part with white and pink spots

At 1105 cm a gravel layer was hit which made further coring impossible.

### 7.2.6. Radiocarbon dates

GrN-18627	196-200 cm	880± 60 BP
GrN-18628	475-480 cm	2920± 60 BP
GrN-18629	595-600 cm	3880± 60 BP
GrN-18630	961-968 cm	9880± 110 BP
GrN-12794	996-999 cm	10,320± 90 BP

### 7.2.7. Pollen assemblage zones

Zone 1 (spectra 1-9): relatively low arboreal pollen values. *Artemisia*, various Compositae present with high percentages. High herb pollen values and AP values of c. 20% including *Juniperus* characterize subzone 1a (spectra 1-4). Subzone 1b (spectra 5-9) is defined by important percentages of *Betula*, *Abies*, *Quercus* and *Tilia*. NAP values, mainly various Compositae, decrease.

Zone 2 (spectra 10-38) is characterized by 70-80% arboreal pollen. Several subzones are identified. Subzone 2a (spectra 10-15) shows high values of *Betula*, *Quercus*, *Ulmus* and especially *Acer*. Gramineae and *Filipendula* are relatively important, whereas Compositae have sharply decreased. Subzone 2b (spectra 16-27) is marked by low values of *Juniperus*, *Betula* and *Acer*, high values of *Abies* and a rapid increase of *Corylus*. Subzone 2c (spectra 28-38): increase in *Juniperus*, *Betula* and *Fagus*, decrease of *Abies*, *Quercus* *cerris*-type and *Corylus*.

Zone 3 (spectra 39-65): the boundary with zone 2 is drawn where *Pinus* values increase. This zone witnesses changes from low to high AP values, which are in turn the basis for a subdivision. In this zone *Olea*, *Castanea*, *Juglans*, *Platanus* and Cerealia-type display continuous

or discontinuous curves. Subzone 3a (spectra 39-42) shows an increase in *Pinus* and Cerealia-type pollen values. Subzone 3b (spectra 43-44) shows the beginning of the *Olea* and *Castanea* curves. *Pinus* values have dropped very low. Subzone 3c (spectra 45-51): *Betula* has almost disappeared. *Fagus* has suddenly increased. *Castanea* slowly increases and *Juglans* is found for the first time in this core. Subzone 3d (spectra 51-57): herb-pollen percentages increase to more than 50%. Cerealia-type and *Plantago lanceolata*-type play an important role. The dominant tree pollen type is *Quercus cerris*-type, *Juglans* is present. Subzone 3e (spectra 57-65): AP values have increased again, especially *Pinus*. Pollen of *Juglans* and Cerealia-type have disappeared or decreased.

### 7.2.8. Discussion

The Late Quaternary vegetation development of the Abant area has been summarized in a poster session during the 5th Optima meeting in Istanbul in 1986. A short discussion is included in van Zeist & Bottema (1991).

A core of 5 m length was studied by Beug (1967). It was collected on the north side of the lake and suffers from differential pollen destruction. It represents the younger part of the core under discussion.

A radiocarbon date of organic remains at 996-999 cm yielded a date of  $10,320 \pm 90$  BP and it is concluded that the lower part, a clay deposit, was formed during the Late Glacial (zones 1a and 1b). In the lowest part of subzone 1a, tree pollen has very low values, c. 20% mainly due to *Pinus* and *Juniperus*. *Cedrus* at c. 4%, reaches the highest values for the whole period, caused by long-distance transport of pollen to the Abant area, which had a very low local pollen production at that time. The presence of *Juniperus* and *Hippophae* pollen points to very open scrub or bushes of light-demanding species. Most characteristic types are *Artemisia*, Chenopodiaceae, various Tubuliflorous and Liguliflorous Compositae, *Ephedra distachya*-type, Caryophyllaceae, *Polygonum aviculare* and *Brassica*-type. Pollen of grasses is low compared to other herbs. The steppic types and the low AP values point to dry conditions.

As may be concluded from the date of  $10,320 \pm 95$  BP, zone 1 represents part of the Late Glacial period as it is known from the Northwest European chronology. Because the clay cannot be dated by the radiocarbon method, and the sedimentation rate cannot be measured, the length of the period is not known. However, there is a visible difference between zone 1a and zone 1b, the latter showing higher tree pollen values, such as *Betula*, *Abies*, *Quercus cerris*-type, *Tilia*, *Carpinus betulus*, *Salix* and *Pinus*. At the same time all herb types decrease gradually. Trees must have expanded either in the Abant area or at lower elevations.

The high *Betula* values especially draw the attention.

Percentages of 15-20% are the highest found so far in Late Quaternary Turkey. For the history of *Betula* in Turkey, the reader is referred especially to Bottema (1990). During zone 1b, birch must have been very common around Abant Gölü, whereas some of the other tree species which are represented in the diagram probably expanded at lower elevations. Birch quite probably formed the upper tree line. Still at the same time pollen of steppe plants is present in reasonably high percentages. It is very likely that during subzone 1b, a birch zone was found on the north-facing slope where at present Nordmann fir is found. At the same time steppe vegetation prevailed on the drier south slope where Austrian pine grows nowadays.

At a depth of 10 m a fundamental change in the AP/NAP ratio is dated  $10,320 \pm 95$  BP. Pollen types responsible for the change are *Quercus cerris*-type, *Ulmus* and *Acer*. The first two types are known to be good pollen producers that are well represented in the pollen precipitation. Pollen of *Acer*, an insect-pollinated taxon, is hardly found, however. In studies on the modern pollen precipitation little if any *Acer* pollen was encountered even when several maple species were growing nearby (Bottema, 1974). Hence it is all the more surprising to find *Acer* values of 10% during this phase. Maple trees must have grown close to the southern shore of the lake, near the marsh where at present Nordmann fir grows. Pollen of maple can hardly have been transported through the air in such quantities. It is more likely that this large amount of *Acer* pollen was washed down the slope into the marsh. On the slope birch still occurred in important numbers, and the disappearing steppe indicators suggest that the south-facing slope north of the lake probably became covered by oak and elm.

The pollen types of *Quercus*, *Ulmus*, *Tilia* and *Acer* cannot be identified further than to genus level. Thus it will be impossible to reconstruct a detailed species composition at this time around Lake Abant. Hegi (1926, vol. V/1: p. 262) describes deciduous mixed forest formed by oak, lime, elm and maple as a relic once very common in the Northern Hemisphere. This association was replaced largely by beech and in the south by sweet chestnut. It is not possible to identify the *Acer* species but information from Davis (1967, vol. 2: p. 509) excludes *Acer pseudoplatanus*, which does not grow higher than c. 1000 m. Mapped for the area, although not precisely for Abant, are *Acer tataricum* (500-1700 m), *A. trautvetteri* (400-2100 m), *A. campestre* (0-2100 m) and *A. platanoides* (500-1900 (2400) m). *Acer platanoides* is the only one of these four species listed in the Optima excursion guide (Özhatay, 1986) to occur in the Abant area nowadays.

The level of spectrum 15 was dated  $9880 \pm 110$  BP (GrN-18630). After this spectrum, at the beginning of subzone 2b, there is a strong increase of *Abies* and the pollen curves of *Corylus*, and *Pinus* gradually rise. Pollen of *Hippophae* disappeared after subzone 2a. Forest is

gradually closing in and at the level of spectrum 21 maximum AP values are established. Light-demanding pioneer species are now outshaded by taller deciduous species and conifers. Towards the second part of subzone 2b *Fagus* slowly increases. In subzone 2b the mixed *Quercus/Tilia/Ulmus* forest is gradually replaced by conifer forest and *Corylus*.

Subzone 2c (spectra 28–38) sees pollen percentages of *Juniperus* and *Betula* on the increase again, probably at the expense of *Quercus cerris*-type. A slight increase in *Fagus* and hornbeam values is visible. The other arboreal types maintain themselves in about the same values. Some way or other more light was created in the forest cover as concluded from the increase in the light-demanding juniper and birch. In subzone 2c the sediment changes from peat to gyttja, suggesting a rise of the local water table. Clearance in the forest around Abant Gölü may have resulted in increasing run-off.

The end of zone 2 can be dated somewhat later than  $3880 \pm 60$  BP (GrN-18629), a date obtained at the level of spectra 36–37. The zone boundary is laid between spectrum 38 and 39, when a distinct increase in *Pinus* pollen took place. At the level of the radiocarbon date, the first anthropogenic indicators are found, viz. Cerealia-type and *Plantago lanceolata*.

Thus, zone 2 dates from c. 10,300 to 3800 years BP, about 6500 uncalibrated radiocarbon years. This is a very long stretch of time. Pollen diagrams from northwestern Europe that cover a comparable length of time are divided into a series of characteristic periods, including the Preboreal, Boreal and Atlantic. Abant Gölü witnessed a continuous forest period during this time, in which the tree pattern varied, and the successive subzones are described in terms of these variations. These subzones cannot easily be brought in line with the European zonation. This is not unexpected, in view of the different vegetation development. The depth of the sediment that constitutes zone 2 is somewhat more than four metres, covering 6500 years. The upper six metres cover about 3800 years.

The beginning of zone 3 (spectrum 39) is laid where *Pinus* increases from about 15% to 45%. It was stated above that Cerealia and plantain pollen first appeared somewhat lower in the core. There might be a connection between the two events, especially if we observe the increase in pine pollen that coincides with the end of the curves of elm and lime. For Europe, the latter two trees are always connected with early farming activity. The appearance of Cerealia-type and *Plantago lanceolata* a little before  $3880 \pm 60$  BP is not uncommon, because the appearance of such indicators can be seen generally in the pollen record of Turkey (Bottema & Woldring, 1990) and Greece (Bottema, 1982; 1984).

In subzone 3a the pollen diagram shows a peak in pine and fir, lower values for hazel, hornbeam, birch and willow and the disappearance of elm and lime. This rather complex event cannot have a natural cause. The species that gave way or disappeared represent various

habitats that would not have been filled in simultaneously by pine. The primary activity must have been the action of man. Did this activity take place around Lake Abant above 1300 m or did the indicative pollen originate from the east of the Bolu area? The latter possibility seems more likely. However, one should not forget that a lake like that of Abant offered fish and this may have been the reason for founding a settlement at this high elevation.

For farming, relatively flat alluvial areas were cleared and possibly deciduous species such as elm, lime, hazel and hornbeam suffered most from this. *Salix* and birch, although occupying different habitats, could have suffered from grazing. They were either actively cut away by man or grazed away by domestic animals. As the pollen spectra are about 120 years apart, one must realize that the environment changed quite slowly. It took generations of farmers to see the landscape change significantly by grazing. The fact that elm disappeared rather abruptly could indicate that it grew on land valued for farming and that was rapidly cleared for crops, but another explanation for the widespread elm decline is possible.

The rise of the pollen values of pine and fir may have been a relative one, caused by the reduction of the pollen production of the lower, deciduous belt. In subzone 3b pollen of *Olea*, *Castanea*, *Juglans* and *Platanus* appear, the indicators of the Beyşehir Occupation phase, an event extensively treated in Bottema & Woldring (1990). In subzone 3b the pressure of the human population must have increased compared with that of subzone 3a, because not only were the indicators of the occupation phase found, but also the arboreal pollen sharply decreased. Birch, pine and fir join the other tree species in displaying a pronounced decline. The mountain belt must have been grazed effectively. Although open space was created, there seem to have been no opportunities for pioneers such as birch. Quite probably the mountain zone was grazed by herds of goat and sheep which are more effective in forest destruction than cattle.

The beginning of the Beyşehir Occupation phase in Abant is dated to around  $2990 \pm 60$  BP (GrN-18628). Subzone 3c covers only two spectra which indicate that recovery of the arboreal vegetation takes place, but the species responsible for the increase are not the same as those that defined the assemblage before subzone 3c. The occupation phase types are still present. Apparently the clearings enabled juniper to expand. Pine became very important but Nordmann fir had played its role and remained at a low level. Beech and oak now became important and these trees may have profited from human impact.

For the explanation of the pollen assemblage of subzone 3c, the forest descriptions in Mayer & Aksoy (1986) are very informative. The most difficult problem for palynologists is to assign the pollen types of one spectrum into vegetation belts. Knowledge about the

present situation is used as the starting point. As we know from fieldwork, *Abies bornmuelleriana* grows on the north- and northwest-facing slopes of Abant (see also Mayer & Aksoy, 1986: fig. 34). On the south slopes *Pinus sylvestris* and somewhat lower down *Pinus nigra* is found.

On the basis of the vegetation description of present-day Abant (7.3.3), several species must be excluded although they are represented in the subfossil pollen precipitation. For instance *Olea*, *Pistacia* and *Quercus calliprinos* cannot have grown at an elevation of 1300 m where winter temperatures are much too low. Yet these pollen types are present, *Olea* even in several percents. These species must have strongly expanded in western and southern Turkey and part of the pollen that they produced was transported to other parts of Turkey, including the Abant area. Also the plane tree (*Platanus orientalis*), which appears in many parts of Turkey at this time, cannot have grown in Abant. Yaltirik (in: Davis, 1982: vol. 7) mentions 1100 m as the upper limit for this tree. According to this author both *Castanea sativa* and *Juglans regia* can be found at the Abant level (1300 m). Their limit is 1550 and 1500 m, respectively. Even in the pollen precipitation of Sülük Gölü (1600 m), a small lake north of Abant that was formed c. 200 years ago by a landslide, *Juglans* pollen is found in small numbers.

The surface samples from Sülük (No. 36) and Abant (Nos 37 and 38) (see also 6.1) demonstrate that even today pollen grains of *Olea* and *Juglans* reach these high altitudes. The highest values are found in Sülük. This may be caused by the location of the sample, namely in the middle of the small lake on the stump of a dead tree that still stood from the time before the lake was formed. In this sample the effect of local pollen is much slighter than in the two Abant samples collected on land covered by vegetation.

In the pollen assemblage, characteristic of the Beyşehir Occupation phase, a gradual increase in *Pinus* pollen is found in the Abant record. It is not clear which changes in the vegetation were caused locally by the activity of man. Pollen of fir, oak and beech gave way to pine. This may have been the result of felling for timber and clearance for crops, but it is not impossible that burning took place to create grazing ground somewhere in the Abant mountains. As the winter conditions are rather harsh with heavy snowfall, grazing could only take place outside that season. The amount of cereal pollen suggests crop cultivation near the edge of the lake and a small community may have lived there, which also used the lake for fishing.

Zone 3d (spectra 52-68) is marked by lower values for the pollen types of the Beyşehir Occupation phase, but this does not decisively mean that human pressure was less. Herb pollen values increased, sometimes up to 50%, and among these types are relatively large amounts of Cerealia-type, *Plantago lanceolata* and more than 15% of spores of *Pteridium*, a fern that is indicative of clearances.

One should keep in mind that clearances of virgin forest initially give an opportunity to numerous other plants, herbs and secondary forest to become established. As the clearance is turned into arable land, ploughing will make these species disappear. Several weed species accompany the crops. Spring-sown cereal crops differ from fields with autumn-sown cereals with regard to weed floras.

In the Abant record, the effects of occupation of coastal lowlands gradually decrease as well as the amount of chestnut trees that must have grown in the local mountains. At the same time the walnut is still present. Cerealia, *Plantago lanceolata* and *Pteridium* values are the highest in the diagram, pointing to important activity in the Abant area.

It seems that human impact has become much less in the next subzone, 3e. Anthropogenic indicators almost disappear and seemingly natural AP values are found in this period. The majority of tree pollen was produced by *Pinus*, but gradually *Abies* and *Fagus* replaced pine pollen.

Calculated from an assumed date of 3300 at the beginning of zone 3b (Beyşehir Occupation phase), zone 3d starts at about 1300 BP, approximately 690 dendro-years AD. For some reason the mountain area was abandoned at that time and forest could regenerate. Minor traces of habitation continued during this period, still indicating the presence of people.

From the upper 60 cm no sediment was recovered. The modern pollen precipitation in Abant Gölü is represented by surface sample No. 37 collected in the peat bog where the coring took place. Surface sample No. 38 was collected outside the fir forest south of the lake near the crest of the ridge. The samples are very much alike, but *Juniperus* is very common on the ridge and very low in the bog. Cyperaceae pollen is common in the bog where they form part of the vegetation, but they distributed little pollen upward to the ridge. The AP values demonstrate some over-representation of tree pollen in general and especially *Pinus* pollen. These values are comparable to the subfossil values of zone 3e and indicate that although the Abant mountains are heavily forested, open space must have been present locally throughout the record.

### 7.3. Yeniçağa Gölü (figs 8 and 10)

#### 7.3.1. Geography

The site was investigated by Beug (1967) and some of the following information is derived from his publication. The lake and marshes of Yeniçağa (40°47'N, 32°2'E) are found 35 km east of Bolu in an east-west oriented valley of c. 7x2.5 km. The valley (976 m) is formed either by karstic or tectonic activity. A branch of the Koroğlu Dağları (c. 10 km southwest of the marsh) reaches 1709 m. The Gökceler Dağı form the northern edge of the basin. Their highest peak rises to 1911 m, some 20 km to the northeast.

### 7.3.2. Climate

For the direct surroundings of Yeniçağa no climatic information is available but nearby Bolu has a weather station. There the average January temperature is 0.1°C and the July/August average measures 19.7°C. Annual precipitation is 534 mm, rather evenly distributed over the year: 156 mm in spring, 96 mm in summer, 112 mm in autumn and 170 mm in winter. Mayer & Aksoy (1986) define the Bolu area as clearly situated in the rain shadow.

### 7.3.3. Present vegetation

The following description of the vegetation is derived from Beug (1967). The direct surroundings are almost or completely deforested. From an elevation of c. 1200 m upward, forest of beech (*Fagus orientalis*) and fir (*Abies nordmanniana*) is found. In lower and subsequently drier parts, scrub forest of oak and forest with developed trees of *Pinus nigra* and *P. sylvestris* are found.

The extensive peat bog was locally drained by small ditches which might originally have been small streams discharging into the lake. The vegetation in the marsh differs locally. Some parts have turned into a kind of grazed meadow where a dense 'turf' (mainly of cf. *Blysmus rufus*) is found. In other parts reeds or medium-sized willows are found, especially closer to the centre and towards the lake. At the bank close to the main road from Bolu to Yeniçağa a large specimen of *Pyrus pyraeaster* was identified by Woldring.

Mayer & Aksoy (1986) postulate a climax vegetation of oak and Austrian pine for the Bolu area. After destruction of this type of forest, *Juniperus* and other plants and shrubs of dry open fields and steppe expanded. The Austrian pine forest is replaced by Scottish pine, mixtures of beech and fir or pure fir forest.

### 7.3.4. The coring

We had been informed by Beug (1967) about the difficulties we could expect during the coring of Yeniçağa Gölü. Beug experienced that a large number of extension rods were needed, because the peat layers in the Yeniçağa basin are thick. We found the upper part very difficult to core because the sediment kept falling out of the sampler leaving hiatuses in the record.

We started to investigate the deposits in the centre of the marsh on the west side of the lake. If during a quick try no bedrock or important change in the sediment was found within a depth of 20 m, we moved roughly a hundred metres to the edge of the basin. At about 75 m from the edge of the peat sediment, the fourth coring hit blue clay at a depth of a little more than 16 m. The few samples which had been cored in the upper 5 m were discarded because we had been able only to collect part of the sediment. For this part of the core Beug's information could be used as he had published the upper 11.5 m.

The upper part (5–11 m) was cored with a Dachnowsky sampler in one hole. From 11 m down to 14.30 m, a 1-m-Livingstone sampler was used, after which the Dachnowsky sampler was used to core down to 17.40 m. Further coring was not possible because of hard clay that could not be sampled.

### 7.3.5. Lithology

575–850 cm	more or less decomposed peat, sometimes with much water
850–900 cm	as above, with wood remains
900–1270 cm	more or less decomposed peat
1270–1390 cm	decomposed peat or green gyttja
1390–1450 cm	partially decomposed peat
1450–1544 cm	peat with shell fragments
1544–1570 cm	grey clay
1570–1600 cm	peat with shell fragments
1600–1618 cm	organic clay
1618–1645 cm	blue clay with shell fragments
1645–1740 cm	blue clay with sand and small stones

### 7.3.6. Radiocarbon dates

GrN-14008	803–809 cm	4430±160 BP
GrN-14009	1255–1263 cm	6920±70 BP
GrN-14010	1339–1345 cm	7280±70 BP
GrN-14011	1535–1540 cm	10,180±120 BP
GrN-12796	1613–1617 cm	12,330±90 BP

### 7.3.7. Pollen assemblage zones

Zone 1 (spectra 1–13) is characterized by high NAP values, mainly *Artemisia*, Compositae and Chenopodiaceae. A subdivision is made on the basis of the behaviour of some tree and herb pollen types. Subzone 1a (spectra 1–2) is strongly dominated by *Artemisia* and shows the highest Chenopodiaceae values in this diagram. Relatively high values for *Ostrya*-type and to a lesser extent for *Juniperus* are present. Subzone 1b (spectra 3–4) shows lower *Artemisia* values, whereas Tubuliflorae and Liguliflorae increase. *Pinus* pollen increases to 25%. Low percentages of *Betula* are found. Subzone 1c (spectrum 5) is assigned to just a single spectrum, which shares its characteristics with subzone 1a. In subzone 1d (spectra 6–10) herb pollen decreases to about 60%, mainly because of a sharp lowering of Compositae values. For the first time a diversity of tree pollen types is found. Most conspicuous are *Quercus cerris*-type, *Juniperus*, *Abies* and *Betula*. Other tree taxa are present for the first time in this subzone, such as *Ulmus*, *Tilia*, *Acer*, *Fagus*, *Corylus*, *Alnus* and *Salix*. Characteristic herb pollen types are *Thalictrum* and Umbelliferae. The identification of subzone 1e (spectra 11–13) was prompted by a strong dominance of herb pollen values. The high NAP values are especially due to Gramineae pollen. Most tree pollen types are absent except for some *Quercus*, *Betula* and *Pinus*.



Zone 2 (spectra 14-30) sees a gradual increase of AP values identical to that in subzone 1d, but the difference is that the herb pollen component is now represented by Gramineae at the expense of *Artemisia* and Chenopodiaceae. Zone 2 is subdivided on the basis of differences in tree pollen composition. Subzone 2a (spectra 14-20) is fairly similar to subzone 1d. *Juniperus* values are somewhat lower and Umbelliferae are somewhat higher. Subzone 2b (spectra 21-25) was identified because of increased values for *Abies* and *Pinus*. During this period a *Fagus* curve started to develop. Subzone 2c (spectra 26-30) witnessed a fall back of AP mainly because of the low values of the coniferous types, whereas *Fagus*, *Carpinus betulus* and *Corylus* increased. The increasing NAP are mainly made up of pollen of Gramineae.

Zone 3 (spectra 31-55) is defined by generally high AP values, fluctuating between 60 and 90%. Diversity in types is at its maximum during a period which is characterized especially by *Pinus*. A subdivision is made on the basis of tree pollen and some herb pollen types. The boundary of subzone 3a (spectra 31-45) and the next one (3b) is laid where Cerealia-type and *Plantago lanceolata* are most in evidence. Soon NAP values increase at the expense of coniferous pollen. Subzone 3b (spectra 46-52) is characterized by increased NAP values. Subzone 3c (spectra 53-55) shows the increase of a limited number of tree types including *Pinus*, *Quercus* and *Fagus*.

### 7.3.8. Discussion

An abridged form of the Yeniçağa diagram was published before (van Zeist & Bottema, 1991). During the field work in the Yeniçağa marshes abundant flowering of cf. *Blysmus* (Cyperaceae family) was observed. Walking through the marsh our boots were dusted yellow by the pollen of these low plants. The Cyperaceae percentages in surface sample 31, taken from mosses growing on lumps of concrete dumped on the turf, only measured 8.8%. The values in the Yeniçağa diagram for this type are considerably higher and this suggests that cf. *Blysmus* pollen immediately precipitates and hardly reaches mosses on stones that are 50 cm high.

The deepest radiocarbon date, at 1613-1617 cm, is 12,330±90 BP. The complete core is 1740 cm long, which may cover about 14,000 years. From about 1600 cm downward, more and more clay is found and from 1618 cm on clay with shells and stones was collected. The date of 14,000 BP for the deepest part is based upon the assumption that the sedimentation rate in the clay is the same as in the dated peat.

In zone 1 pollen of herbs, mostly steppe plants, dominated. Pollen of *Artemisia*, Tubuliflorae, Liguliflorae, and *Ephedra distachya*-type is dominant in the greater part of this section. In the first two spectra, tree pollen is almost absent and steppe vegetation must have prevailed. A slight increase in arboreal pollen is mainly caused by *Pinus* and *Betula*, whereas *Artemisia* values

decrease from more than 40% at first to less than 10% in the upper part of this zone.

In the next spectrum, No. 5 (subzone 1c), conditions of subzone 1a seem to have returned. To explain these fluctuations is not simple. The number of spectra is too low to prove a distinct trend. Still the behaviour of the Tubuliflorae and Liguliflorae pollen values may indicate a rise in temperature during subzone 1b. This increase may have been caused by oxidation of less resistant pollen types and one considers to over-representation of such composite pollen. At the same time an increase in pioneer forest may have occurred, pointing to a higher temperature.

Somewhat before 12,330 BP an increase in arboreal pollen percentages took place that heralded the dominance of this group in the Holocene. From 12,330 to 10,180 (both of these are radiocarbon dates), various tree types appear and attain major percentages (subzone 1d). Comparatively high values of *Quercus*, *Pinus* and *Juniperus* point to the development of open forest on the mountains around the Yeniçağa basin. On higher parts *Abies* forest expanded, pushing *Betula* to even higher elevations. Where conditions were more favourable for tree growth, probably towards the Black Sea, temperate species such as *Tilia*, *Ulmus*, *Acer*, *Fagus* and *Corylus* increased.

In zone 1, there is a shift from pine pollen to that of deciduous tree types and fir. Spectrum 12, the beginning of subzone 1e, records a sharp decrease of all arboreal types. The value of Gramineae pollen is doubled to 80% and only 5% tree pollen is found. At the same time a shift in sedimentation takes place. The peat deposit is followed by clay, suggesting a return to glacial conditions. Many herb taxa show lower values, but pollen of typical steppe taxa, *Artemisia* and Chenopodiaceae, remains at the same level. Arboreal pollen increases only towards the end of subzone 1e. At the level where the steppe-indicating types, *Artemisia* and Chenopodiaceae, decrease, a date of 10,180±120 BP is obtained. Calculated from this date and that of 12,330±90 BP for the level of 1613-1617 cm, the age of spectrum 12 would be about 11,090 BP.

The course of the pollen curves and the chronology of zone 1, supplied by the radiocarbon dates, provide a sequence that fits the Late Glacial of northwestern Europe. Subzones 1a-c represent the Older Dryas. The *Pinus* values of spectrum 4 are not considered sufficient evidence to identify the so-called Bølling oscillation. Subzone 1d represents the Allerød and zone 1e is equated with the Younger Dryas.

Some climatical conclusions are drawn from the vegetation evidence. In subzones 1a and b, temperature and precipitation were unfavourable for tree growth. Low temperatures preceding the Allerød are a global phenomenon. The high values of Tubuliflorous and Liguliflorous pollen point to dry conditions caused by relatively high summer temperatures.

In subzone 1d, identified as the Allerød, proof of

global warming is derived from other sources. The expansion of forest in the Yeniçağa area, concluded from the pollen evidence, was made possible by an increase in temperature, but precipitation must also have been higher at that time. Otherwise the effect would have been an increase in steppe elements.

The end of zone 1 (subzone 1e, the Younger Dryas as it is known in Europe) saw unfavourable conditions for the growth of trees, possibly a drier climate, and lower temperatures than during the Allerød. In Yeniçağa the disappearance of tree pollen may point to such a change. As to the moisture level of this period, indications differ from those of the Older Dryas. Compositae do not play a role and the pollen of Gramineae amounts to a much higher value than before the Allerød. One is inclined to conclude that the Younger Dryas in the Yeniçağa area was cold but less dry than the Older Dryas.

From zone 2, beginning somewhat before 10,180 BP, forest expanded in this part of northern Turkey. In the Yeniçağa basin, oak and juniper were the main constituents of a rather open forest. At elevations somewhat higher than the valley, fir occurred. Pines initially were hardly found in this area, but gradually became established on the mountains around the marshes. Open space among the trees is concluded from the NAP values, which gradually decreased from about 80% to 40% within subzone 2a. Most of the NAP is Gramineae pollen. It is possible that part of this pollen was produced by plants growing in the marsh but this part will not have been important, since Gramineae only amount to 11.4% at present in surface sample 31. In subzone 2a most of the steppe plants in the upland were replaced by grass vegetation.

*Betula*, which occurred in some numbers in the previous zone, disappeared from the area. Very low numbers of *Ulmus*, *Tilia*, *Fagus* and *Corylus* can be ascribed to long-distance transport from an area closer to the Black Sea. The expansion of arboreal pollen does, for the time being, halt about 8700 BP, calculated from the available radiocarbon dates.

The next phase in the Yeniçağa vegetation history demonstrates a maximum for *Pinus* and *Abies*, whereas a decrease in *Quercus* is visible. This subzone witnesses the beginning of continuous curves for a group of deciduous species: *Fagus*, *Corylus* and *Carpinus betulus*. Very probably the valley was gradually conquered by coniferous forest, which replaced the deciduous oak forest. Especially *Abies*, with pollen percentages of up to 20%, must have covered most of the flanks of the valley and the north-facing slopes of the Kocabaşı Dağ, south of the lake. This vegetation phase lasted until about 7280±70 BP.

At the level of spectrum 24 (1390 cm) a change in sediment took place. The rather decomposed peat turns into a peaty gyttja and finally into green gyttja. Subzone 2c shows a pollen assemblage that is different from the subzone preceding it and certainly from the zone that

follows. Apart from the difference in pollen content, the sediment deposited during this period is different. The sedimentation rate of the Yeniçağa core peaks in this part, where 80 cm of gyttja were deposited in 360 radiocarbon years (0.22 cm/y, whereas the average for the whole core is 0.13 cm/y for 12,330 years). It is clear from the lithology that the water level of the Yeniçağa basin rose between 7200 and 6900 BP. This may have been a purely local phenomenon, for instance the blocking of an outlet. On the other hand a change in climate may have occurred. This period, the beginning of the Atlantic time, is thought to have caused a moister climate in northwestern Europe. In the nearby pollen record of Abant Gölü (7.3.8) this period would have been represented at about 880 cm depth, calculated from the radiocarbon date of 12,320 BP at 1000 cm and assuming a date of 3300 BP for the beginning of subzone 3b. However, there are no pollen spectra that demonstrate a wet period to be correlated with the Yeniçağa feature. This suggests that the wet phase in Yeniçağa is of local origin. The decrease in *Pinus* and *Abies* during this period especially draws the attention. Deposition in open water may have depressed the floating pollen types of *Pinus* and *Abies* at the coring site, since the bulk of this pollen may have moved towards the edge of the water with the waves.

After c. 6900 BP, the beginning of zone 2, a pollen picture evolves that very probably represents the potential vegetation of today. From 6900 to about 4000 BP the pollen values fluctuate within a consistent pattern; during this time, even if there was human habitation, no great impact upon the forest can be traced. According to the forest description given by Mayer & Aksoy (1986), several species cover considerable altitudinal ranges, depending upon the kind of substratum and exposure. *Quercus* species and *Pinus nigra* probably grew in the valley and on the adjacent slopes. Various deciduous tree species will have occurred in smaller numbers somewhere in the area.

Soon *Abies* will have covered the higher parts of the mountains together with *Fagus*. The tops of the mountains had lost the birches and during this period *Pinus sylvestris* formed the upper belt.

Zone 3a covers the Atlantic period, as it is known in northwestern Europe, and a small part of the following Subboreal. Not only the pollen assemblage points to different conditions, also the local spore curve of *Dryopteris*-type is indicative in this respect. Ferns became very common in the marsh during zones 3a and 3b.

A change in the composition of the pollen assemblage of subzone 3b is ascribed to human activity. Pollen values of trees decrease sharply from spectrum 46 onward. Herb-pollen percentages increase from c. 15% to c. 40%. Cerealia-type pollen is prominent, *Plantago lanceolata*-type appears, low values of *Sanguisorba minor*-type are found. The high values of Gramineae indicate open space as a result of the destruction of the

forest. Soon, while the Yeniçağa basin was increasingly being exploited, certain parts must have been abandoned and left to regenerate. Calculated on the basis of the radiocarbon date  $4430 \pm 160$  BP at 803–809 cm, subzone 3b lasted until 3570 BP. As early as about 4100 BP, at a depth of c. 750 cm, pollen of *Pinus*, *Fagus* and *Carpinus betulus* begins to expand again. The evidence from the Yeniçağa core ends at 500 cm depth, dated at about 2800 BP, because no good recovery could be effected.

For the development of the subsequent four millennia in Yeniçağa the diagram prepared by Beug (1967) is used. Beug collected 11.50 m of sediment in the western part of the marsh in 1957. As we too cored at the western side, our evidence originates from the same area as that investigated by Beug. Beug's diagram is dated  $3980 \pm 90$  (H 577–553) at 7.6 m and  $1655 \pm 70$  (H 567–596) at 2.6 m. By extrapolation Beug arrived at an age of c. 5250 BP for the lowest part. These dates and the course of the pollen curves indicate that there is an overlap between Beug's diagram and the present record.

At 8.0 m in Beug's (1967: p. 352) Yeniçağa diagram *Pinus* pollen sharply decreases, whereas *Fagus* values show a peak. At 7.6 m the sediment is dated  $3980 \pm 90$  BP, converted by Beug to 2020 BC in his diagram (Beug, 1967: fig. 2). The new diagram shows a comparable event at the boundary of subzones 3a and 3b, likewise at a depth of 8 m. The maximum of the pine period, between spectra 45 and 46 where the zone boundary is laid, is dated  $4430 \pm 160$  BP.

The missing part in the Yeniçağa record, from 2800 BP up to the present, can be read from Beug's diagram. This section begins at 5 m in both cores.

The younger millennia, according to Beug, did not see any important changes in vegetation cover. From about AD 700, pollen of deciduous oak increased at the expense of that of pine and this lasted to about AD 1200. Beech shows somewhat higher values, and a slight increase in *Juniperus* and a series of deciduous taxa is visible in this period. One could deduce a regeneration of the forest around Yeniçağa, but Cerealia-type pollen also increases and this could point to an expansion of farming. The significant lowering of *Pinus* pollen could be ascribed to herding activity on the slopes, lumbering and burning.

In the upper part a dominance of *Pinus* is witnessed, which is paralleled in large parts of Anatolia. The fairly recent high values of *Pinus* are clearly an overrepresentation that could occur at a time when other, mainly deciduous species were reduced or even removed completely.

### 7.3.9. Palaeomaps

The transect of pollen diagrams obtained for the northwestern part of the area discussed in this paper, from Abant Gölü down to the Black Sea, seems to be ideal for the construction of palaeomaps. Unfortunately,

only the records of Abant and Yeniçağa Gölü represent a longer period, part of the Late Glacial and the following Holocene. The diagram of Melen Gölü covers the last three millennia and the coastal sites of Küçük Akgöl and Adatepe are even younger. van Zeist & Bottema (1991) construct palaeomaps for three periods: 12,000, 10,000 and 6000 BP, based upon the information of the Abant and Yeniçağa record. Such 'time windows' were chosen because they represent clearly different vegetations due to conspicuous differences in conditions. The period after 6000 BP definitely saw changes which are elucidated in sections 7.2, 7.5 and 7.6. It is, however, very difficult to draw a map for a date after 6000 BP because the influence of human habitation is clearly felt and overrides any climatic changes or vegetation succession. The three palaeomaps prepared for TAVO are shown as figures 14–16. Relevant information on the vegetation development presented in these maps is given in this section, section 7.2 and in more detail in van Zeist & Bottema (1991).

### 7.4. Melen Gölü (figs 8 and 11)

#### 7.4.1. Geography

The site of Melen Gölü is also recorded on maps as 'Eften Gölü' ( $40^{\circ}46'N$ ,  $31^{\circ}3'E$ ). The name Melen Gölü seems to be the one commonly used by the local people. The lake of Melen lies in the lowland area at the northern foot of the Elmacık mountains, c. 12 km southwest of the town of Düzce, at an elevation of 125 m (fig. 8). South of Melen Gölü a road runs along the steep slope bordering the water. About halfway along it a narrow strip of marsh is found between the mountains and the lake. The lake must be very shallow there because herons and black storks are seen standing up to their hocks far out in the lake.

Several rivers discharge into the lake. West of the lake a river is crossed by the road from Paşakonağı (Düzce) to Gölyaka. In the north the Asar Suyu runs from the Bolu area to discharge into the lake. From the Bakacak Tepesi (1602 m) a stream runs northward to end in the eastern part of the lake. This stream must have carried a large amount of gravel and sand into the eastern plain. Many small streams are braiding through watery flats. It was difficult to walk over these flats because of the very soft mud layers among the gravel. Coring failed because of the many gravel layers. Seepage is responsible for the occurrence of great numbers of small springs.

In the area north and northeast of the lake the water regime is of a different nature. Here most of the water seems to arrive during the winter half year. Dry sand layers with intercalated pebble and silt can be seen in this area. Only the main stream beds in the basin contain water.

#### 7.4.2. Climate

According to TAVO maps A IV 2-4 (Alex, 1983b,c; 1984), Melen Gölü lies in the area that catches more than 1000 mm of rain, while the temperature zones are 0-5°C for January and 20-25°C for July. The nearest weather station is that of Adapazarı (30 m). The average January temperature there is 5.7°C, while for July 22.8°C is recorded. Precipitation is 798 mm, of which 186 mm falls in spring, 139 mm during the summer, 202 mm in the autumn and 271 mm in winter (Mayer & Aksoy, 1986). Because Melen Gölü lies just north of the Elmacık mountains, precipitation is probably higher there than the amount recorded for Adapazarı.

#### 7.4.3. Present vegetation

The area north of Melen Gölü is completely cultivated. Poplar is planted as a lane tree and in forests for economic purposes. The slope which borders the south side of the lake is covered with hazel plantations, deciduous scrub and forest. Large trees include *Fraxinus excelsior*, *Tilia argentea* and *Castanea sativa*. Along the edge of the lake *Alnus* is found. East of the lake, where small seepage springs occur in gravel flats, *Catabrosa*, *Ranunculus* and *Mentha* were seen, together with scattered willow trees. The marsh is grazed by cattle. The narrow marsh strip at the south side of the lake shows *Phragmites* and two species of *Sparganium*. *Trapa natans* grows in the shallow water near the shore as well as hundreds of metres into the lake.

For the Adapazarı area, c. 50 km west of Melen Gölü at 50-100 m, Mayer & Aksoy (1986) give the following forest on wet soil: dense forest of *Alnus glutinosa* ssp. *glutinosa* with *Periploca graeca*, *Rubus hirtus*, *Smilax excelsa*, *Pyracantha coccinea* and *Cornus mas*. Furthermore *Carpinus betulus*, *Corylus avellana*, *Acer campestre*, *Ulmus minor*, *Platanus orientalis* and *Fraxinus angustifolia* ssp. *oxycarpa* are mentioned.

#### 7.4.4. The coring

The coring took place 27 m away from an overhead telephone line and about 40 m from the road which was cut into the slope. To construct the road, soil had been pushed down the slope towards the lake. In the narrow strip with reeds, in a very soft sediment, a coring place was prepared by flattening the *Sparganium* and *Phragmites* and laying planks on top of them. This did not, however, save the coring team from slowly sinking half a metre down into the marsh. At first a Dachnowsky sampler of 25 cm was used up to a depth of 13.30 m. From this point up to 14.75 m a Livingstone sampler (35 cm capacity) was used.

The very homogeneous soft grey clay contains pollen which has a very good preservation and a good concentration. The samples from the core were analyzed with an average distance of 20 cm over a depth of 1470

cm. No recovery was obtained for 1320-1360 cm, whereas the lowermost metre was analyzed every 10 cm, so as to produce a higher resolution.

#### 7.4.5. Lithology

5-1475 cm very soft light grey clay/gyttja

The clay gyttja occasionally contained other material: *Phragmites* roots at 225-250 cm, 610-620 cm; gravel at 1450-1475 cm; shell fragments at 500-525 cm, 709-723 cm, 790 cm, 955-980 cm, 1400-1435 cm and 1450-1460 cm; fruits of *Trapa natans* at 145 cm.

#### 7.4.6. Radiocarbon dates

GrN-12797 1031-1037 cm 2840±100 BP

#### 7.4.7. Pollen assemblage zones

The percentages of the pollen types displayed as curves in the diagram of Melen Gölü have been calculated on the basis of a pollen sum including all pollen types apart from those of aquatics. It is difficult to decide to what extent some of the Gramineae and Cyperaceae were produced by local marsh plants but because their values are not very high, they are included in the pollen sum.

Zone 1 (spectra 1-7): high values for *Fagus* and *Abies*.

Zone 2 (spectra 8-76): pollen of *Olea*, *Castanea*, *Juglans* and *Platanus* are present. This zone is divided into four subzones. In subzone 2a (spectra 8-25) the values of *Alnus* and *Quercus cerris*-type are high, those for *Fagus*, *Pinus* and *Carpinus* are low. In subzone 2b (spectra 26-31) lower values for *Alnus*, but an increase in *Carpinus betulus* and *Pinus*. In subzone 2c (spectra 32-44) low values for *Carpinus betulus*, *Pinus* and AP in general. In subzone 2d (spectra 45-76): high values for *Fagus*, while *Pinus* and *Quercus* decrease.

#### 7.4.8. Discussion

The only suitable coring site in the Melen Gölü basin was found at the steep south shore. The other sides of the lake were flat, open areas which have a vegetation that nowadays differs very much from that of the mountain slope. These differences must also have played a role during prehistoric times. For instance, farming and grazing will have developed mostly on the flats whereas the mountainside will have seen a different form of exploitation. The pollen content of the core is likely to have been determined more by the plant cover of the steep Elmacık mountain than by the other areas.

The diagram is dominated by arboreal pollen. Where the arboreal pollen values are lowest, in zone 2b, they still are more than 70%. During most of the last 4000 years, AP values were 80-95% at the south shore of Melen Gölü. Tree types with important values are *Alnus*, *Carpinus betulus*, *Fagus* and *Quercus cerris*-type. Lower percentages are attained by *Corylus*, *Juniperus*,

*Castanea*, *Fraxinus excelsior*, *Abies*, *Platanus*, *Salix*, *Tilia*, *Ulmus* and *Vitis*. Species with very low values in discontinuous curves, and sometimes found in part of the diagram only, are *Acer*, *Pistacia*, *Ilex*, *Hedera*, *Betula*, *Ostrya/Carpinus orientalis*, *Buxus*, *Rhododendron*, *Quercus calliprinos*-type, *Olea*, *Populus* and *Taxus*. The low percentages can partly be explained by long-distance transport as with *Betula* (fig. 14), partly by low pollen production and poor dispersal as with *Ilex* or by a small number of the producing tree species.

The grouping of the pollen types into vegetational units is done on the basis of the plant-geographical information from Mayer & Aksoy (1986), Frey & Kürschner (1989), Quézel & Barbéro (1985) and van Zeist & Bottema (1991). The present pollen precipitation can be read from the surface samples and to some extent from the topmost sample of the core itself. The upper spectrum of the Melen pollen diagram originates from a depth of 60 cm and presumably reflects the vegetation of 150 years ago. However, the upper part of the sediment was very soft and thus the age may be younger. How much younger cannot easily be established and the pollen composition of the upper spectrum is no direct reflection of the vegetation found around Melen nowadays. This conclusion can be drawn from the results of surface sample No. 33 taken near the core location. If these results are compared with the general description of the vegetation, some features, not found in the top spectrum No. 76 at 60 cm, are present in the modern pollen rain. A value of 14.2% for *Corylus* is explained by the presence of commercial hazel plantations on the slope. The upper part of the pollen diagram shows *Corylus* values of about 3% and commercial hazel growing must have developed later. The mountain beech forest has been heavily exploited and its pollen percentages have decreased sharply from about 25 to 4.6% during the course of the pollen record. The composition of the modern pollen rain combined with the vegetation description and the plant-geographical information seems to be the most reasonable basis for establishing a pollen grouping.

Local forest, along the shores of Melen Gölü and on the flats around the lake, include *Alnus glutinosa* (alder), *Salix* (willow), *Fraxinus excelsior* (ash) and *Populus* (poplar). For the local mountain forest, especially on the north slopes of the Elmacık mountains, are mentioned: *Corylus*, *Carpinus betulus* (hornbeam), *Juniperus* (juniper), *Quercus* species, *Castanea sativa* (sweet chestnut), *Juglans regia* (walnut), *Tilia* (lime), *Ulmus* (elm) and *Platanus orientalis* (plane tree). Higher on the Elmacık mountain slopes above Melen Gölü, forest of *Fagus orientalis*, *Abies nordmanniana*, *Pinus*, *Carpinus betulus*, *Tilia*, *Ulmus*, *Acer* and *Taxus baccata* will have occurred. In cases where only the genus name is given in this description it means that the palynological identification is limited to that level, as for instance for *Quercus* or *Ulmus*. When the species name is given it does not however imply that the respective pollen can

be identified to the species level. The species may be the only representative of the genus in that part of the world, for instance *Taxus baccata* or *Abies nordmanniana*.

Pollen produced by forest growing on more distant mountains can be considered to reflect long-distance transport. There are also some low percentages of pollen types produced by species which are not found in the area today. Their values do not suggest that they occurred in the vicinity of Melen Gölü during the time covered by the diagram. For instance, pollen of *Picea orientalis* originates from northeastern Turkey, east of Ordu.

*Cedrus* grows at high altitudes in the south along the Mediterranean, from Köyceğiz up to Maraz (Karabannaras), and a very small stand in the north near Erbaa. At Melen Gölü, *Cedrus* pollen will probably be carried in with wind blowing inland during the spring from the Antalya region. *Olea* is grown at lower levels west of Adapazarı around the Gulf of İzmit and pollen from that area may have reached Melen Gölü.

The parasitic species *Viscum* and *Loranthus* are present with scattered grains. *Viscum* has many host species, deciduous as well as coniferous trees, whereas *Loranthus* may be more specific and this taxon is reported to be found on Fagaceae (Davis, 1982), especially *Quercus pubescens*, *Q. cerris* and to a lesser extent *Castanea sativa* (Hegi, 1981, vol. III: p. 320).

The herb types in this diagram never reach high values and ground cover is especially well-represented by the spores of *Pteridium*. Non-arboreal pollen was produced by local marsh vegetation or plants growing in the water, by crops planted by farmers or by herbs growing in clearings where the dense forest was opened up.

We are informed on c. 4000 <sup>14</sup>C years of vegetation development, judging by a date of 2840±100 BP. About 4000 years ago forest vegetation was maximally developed. Montane forest was made up of beech and pine. Lime, hornbeam and elm were common and hop hornbeam (*Ostrya carpinifolia*) must have occurred regularly in the Melen region. The last-named tree produces pollen which cannot be separated from that of *Carpinus orientalis*, the oriental hornbeam, by means of light microscopy. However, Davis (1982, vol. 7: p. 892) mentions *Ostrya carpinifolia* for the Bolu area close to the Elmacık mountains. *Carpinus orientalis* is found nowadays from Kastamonu eastward and therefore is less likely to be found in the subfossil record.

Towards the top of zone 1 (c. 1410 cm) a change in pollen values takes place, especially in the arboreal pollen value which drops from c. 95% to 80%. This is caused by a decrease of *Fagus*, *Abies*, *Pinus* and *Carpinus betulus*, probably due to lumbering. This is concluded from the increase of bracken spores (*Pteridium*), a sign that the forest was opened up.

The anthropogenic activity continues in the next subzone, 2a, where no regeneration from human impact

can be seen. Bracken retains more or less the same values, whereas pollen values of some tree species, viz. *Carpinus betulus*, *Fagus* and *Abies* still decrease. Deciduous oak and *Ostrya carpinifolia* increase. Either these trees increased in those localities where beech and fir had been cut, or the pollen increase is only a relative one. The same can be said for trees which occurred along water and in marsh, *Alnus* and *Salix*.

One could perhaps explain the gradual changes in the pollen diagram by human exploitation. An initial phase is found between 1360 and 1300 cm, covering a period of about 150 years (estimate of 0.36 cm/y). Oak pollen values continue to rise from c. 10 to 17%, either spared by man for economic reasons or simply showing a relative increase, because other species had been reduced in numbers.

An important aspect found in many pollen diagrams from Turkey and Greece is the simultaneous appearance of pollen of *Juglans*, *Platanus*, *Castanea*, *Olea*, *Cerealia*, *Humulus/Cannabis*, *Plantago lanceolata* and *Rumex acetosa*-type. This appearance, the so-called Beyşehir Occupation phase, is treated in section 8. The human activity will have taken place only in part of the Melen area because the environment was not suitable for human settlement and exploitation everywhere. The steep south side of the lake, where the core was taken, will not have attracted people as long as ample space was still available elsewhere. Nor will the eastern spring-fed marsh have attracted many settlers. It is difficult to locate the activity indicated by the pollen record in the Melen area. Certainly part of the activity revealed by the palynological evidence will have taken place outside the area, either towards the tree limit where natural meadows could be grazed or extended into marginal forest, or towards the Mediterranean coast where olives could be grown.

From the time of the deposition of the sediment at 1300 cm (spectrum 12) pollen values for sweet chestnut, walnut, and plane tree as well as the spore percentages of bracken increase. At this point lime has disappeared and deciduous oak pollen decreases, whereas coniferous pollen increases. An explanation may be that the local forest was destroyed and to some extent replaced by orchards. The pollen of fir and pine only increased relatively because of lowered values for local deciduous forest. This is suggested because the increase in coniferous pollen is not accompanied by a decrease in non-arboreal types.

In earlier publications (e.g. Bottema & Woldring, 1990) it was stated that human exploitation around 3300 BP must have increased over a considerable area. In the Melen area this could be deduced from the increase of olive pollen values. Olives may not have occurred near to the coring site but their values, although low, are never higher than at this level of the pollen diagram.

During the time of subzone 2a, up to the point dated by radiocarbon to 2840 BP or about 100 years later, the

Melen pollen diagram indicates increased activity. In the next subzone, 2b, from about 2700 BP onward, an important regeneration of the vegetation occurred. Total tree pollen values increase to values nearly as high as in zone 1. Spores of bracken (*Pteridium*) decrease. Pollen of *Juglans* is almost absent, that of *Castanea* is considerably lowered. *Platanus* values do not change much and this could be an indication that the first two species were dependent upon cultivation and management, whereas the plane tree seems merely to have profited from the effect man had upon the vegetation. As plane trees can live for hundreds of years, they could have easily spanned subzone 2b. Beech and Nordmann fir forest that was widespread during zone 1, decreased to a large extent during subzone 2b. The increase in total tree pollen was now to some extent caused by *Carpinus betulus*, but mostly by a rise in *Pinus* from c. 10 to 50%. Herbs, grasses and ribwort plantain which indicate open space decreased to near-absence.

A renewed attack upon the vegetation took place at about 2400 BP, at the bottom of subzone 2c. The characteristics are very similar to those of subzone 2a and an interpretation on the basis of the pollen record must be the same as that given for zone 1. Values for *Vitis* and Gramineae are somewhat higher than in subzone 2a. *Vitis* pollen could have been produced by wild vines which formed part of the riverine forest or more in general forest in moist places where light could penetrate. There are indications for viticulture in the Near East since the mid-fourth millennium BC in Iran (Miller, 1991), either in the form of charred grape pips or of wine residue in pottery, outside the distribution area of wild vine. In Melen, 4% of *Vitis* pollen is found in subzone 2b. Such values are not attained even in a sample from the middle of an Italian vineyard, investigated by Henk Woldring. Modern cultivated vine seems to be a poor pollen producer and on the whole self-fertilizing. Wild vine produces larger amounts of pollen and the species is regularly encountered in subfossil spectra of prehistoric times. The early domesticates may have been reasonably prolific pollen producers and dispersers, so that curves in diagrams could have been produced by vineyards. Inevitably the type appears or increases with the set of pollen types of the Beyşehir Occupation phase indicating human activity. Another possibility remains, that forest was opened up by cutting and that *Vitis* spread along the margins which were thus created. However, one must realize that the possibility of grape growing existed already for a long time.

An increase of Gramineae values from about 2-5% to 5-7.5% supports the idea that the Melen region was exploited. The amount of open terrain in which grasses grew increased; this may well have been grazed.

At about 1800 BP (AD 150) a regeneration of the forest took place as is evident from the total arboreal pollen values. In the first part of subzone 2d up to

spectra 59-62 *Tilia* shows a remarkable increase where it had been very rare for millennia. At about AD 1150 (still assuming a constant sedimentation rate) lime decreased again, as hornbeam and oak had done before. Alder and willow, probably growing on the lake margin as they do nowadays, expanded. The total tree pollen value is still remarkably high in the upper subzone 2d. Only the topmost spectrum 76 shows a decrease of the total arboreal pollen to about 70%. The AP value measured in the surface-sample spectrum, taken at a distance of 10 metres from the core, amounts to c. 60%. It is concluded from the upper samples that the destruction of a large part of the natural forest took place during the last few centuries. It is remarkable that elm suffered little from human activity until very recently, when it became absent in the modern pollen rain.

#### 7.4.9. Local vegetation and sediment development

In about 4000 years 15 metres of soft clay were deposited in the southern part of the lake. At present the lake is very shallow and small rowing boats used for fishing have to follow certain routes where it is deep enough. Several hundred metres towards the centre, the lake is still shallow, since a dozen black storks could be seen wading there. The problem is which pollen types are indicative of water level. Given the kind of sediment found in the Melen basin, the material must largely have arrived from the east. In the east part of the lake heavy gravels occur which represent the heaviest fraction of the deposits. Sands were deposited in the northeast.

In the southwest not much material was brought in from the steep mountainside. This is where the very fine silty fraction from the material that came from the east, settled. Even today the steep mountainside is very close to the shore and this situation was also found at the time when the lake was 15 m deeper. Far into the lake as well as close to the edge *Trapa natans* floats on the water. Pollen of this plant appears suddenly at a depth of 2 m, less than five centuries ago. Gradually the basin was filled in as a result of the erosion on the slopes around it.

Pollen of many water plant taxa occurs in the sediment but never attains important values. Conditions for Sparganiaceae were more suitable in the marshes in the east. Locally the belt of *Phragmites* and *Sparganium* is no more than 10 m wide with some clusters of vegetation extending into the lake. The belt of reeds did not produce a significant number of Gramineae pollen.

### 7.5. Küçük Akgöl (figs 8 and 12)

#### 7.5.1. Geography

Küçük Akgöl (40°52'N, 30°26'E) is a small lake, found c. 18 km north of the town of Adapazarı, at an altitude of c. 50 m (fig. 8). The lake measures some 500 m in diameter. Separated by a low ridge, at c. 2 km to the

southwest of Küçük Akgöl, lies the somewhat larger lake Taskışığı Gölü. Because of slippery dirt roads, Küçük Akgöl had to be reached on foot from a village off the main road Adapazarı-Karasu. Taskışığı Gölü was not reached at all.

The area is an undulating lowland, sometimes with steeper hills on which scrub or remnants of deciduous forest are present. No outlet was seen in Küçük Akgöl, but Taskışığı Gölü waters towards the Sakarya (*Yeni Türkiye Atlası*, 1977). Some 20 km to the east lies Solmen Gölü. An attempt was made to visit this lake but the dirt tracks leading to it were impassable because of the rain.

#### 7.5.2. Climate

Data on the climate of the Sakarya valley in the vicinity of Küçük Akgöl are derived from TAVO (Alex, 1983b,c; 1984). The average January temperature is in the order of 5-10°C, and for July c. 22.5°C. Annual precipitation averages about 800 mm.

#### 7.5.3. Present vegetation

Most of the area north of Adapazarı is cultivated. Only where a high groundwater table occurs, remnants of the natural vegetation are encountered. Partly this is marsh vegetation with *Sparganium* and *Mentha aquatica*. Around Solmen Gölü there is forest of hornbeam and deciduous oak.

On the southeast side of Küçük Akgöl marshes are found with reeds and rushes. Along the lake's edge poplar and willow occur. The low hills carry remnants of forest with various oak species including *Quercus cf. pubescens*. Furthermore *Phillyrea*, *Cornus mas* (very common), *Fraxinus excelsior* and *Rubus* are found.

Mayer & Aksoy (1986) describe riverine forest between Hendek and Adapazarı, the so-called 'Süleymanlıye Disbudak' forest, that has been partly destroyed. This forest is dominated by *Fraxinus angustifolia* ssp. *oxycarpa*. Furthermore *Ulmus minor*, *Carpinus betulus*, *Quercus robur*, *Alnus glutinosa*, *Acer campestre*, *Salix caprea*, *Populus alba*, *Platanus orientalis*, *Cornus sanguinea* and *Crataegus monogyna* are found.

#### 7.5.4. The coring

A core was taken at the southeast edge of the lake, in a marshy area. The sampling was stopped because of a gravel layer which could not be penetrated.

#### 7.5.5. Lithology

0- 55 cm	peaty soil with recent roots
55- 70 cm	water
70-125 cm	brown gyttja
125-165 cm	light grey gyttja with shell fragments



165-172 cm	water
172-225 cm	dark gyttja with shell fragments
225-325 cm	grey-blue clay gyttja with shell fragments, small mussels
325-427 cm	sandy grey-blue clay with shell fragments and small stones at
385-390 cm	
427-522 cm	grey sandy clay with yellow, brown and black spots, sometimes with gravel or lime concretions (475 cm). Lower part more brown to red in colour.

#### 7.5.6. Radiocarbon dates

GrN-12793	217-220 cm	2020±60 BP
GrN-18626	290-300 cm	2600±80 BP

#### 7.5.7. Pollen assemblage zones

Zone 1 (spectra 1-13): high herb pollen values, primarily *Plantago lanceolata*-type, *Liguliflorae*, and spores of *Pteridium*.

Zone 2 (spectra 14-22): high AP values, comprising *Pinus*, *Carpinus betulus*, *Fagus*, *Ulmus* and *Alnus*. Herb pollen has decreased to about 30% at the beginning of this zone and finally amounts to 5%. Two subzones are identified. Zone 2a (spectra 14-16) with relatively high NAP values and zone 2b (spectra 16-22) with AP values ranging from 5 to 10%. The difference between the two subzones is also illustrated by the absence of *Castanea* and the strong decrease of *Juglans* in the upper zone.

The pollen content of the sediment between 420 and 522 cm was too low for a reliable pollen count.

#### 7.5.8. Discussion

The area around Küçük Akgöl in the valley of the Sakarya river was intensively used by people during the time of zone 1. All forms of forest must have suffered heavily from some kind of exploitation or clearing. Part of the area will have been used for farmland as can be concluded from the cereal-type pollen grains. Most of the land, however, was used for grazing as is shown by very high values of *Plantago lanceolata*. Other herb types, for instance *Polygonum aviculare*-type, *Trifolium*-type and the spores of *Pteridium*, indicate the presence of human habitation. Deposition of mudflats caused by erosion is deduced from high *Euphorbia* values, the presence of open terrain from high values of *Liguliflorae*.

The lowest part of the core has an age of about 3900 uncalibrated radiocarbon years, assuming a constant sedimentation rate. Tree pollen values are low, especially at the beginning of zone 1, and changing hydrological conditions are deduced from the poor pollen preservation. Soon, at about 390 cm (spectrum 4), pollen of deciduous oak, beech, hornbeam and walnut appear or increase. The estimated age, the pollen composition,

especially the deciduous types, and the appearance of the walnut all point to the Beyşehir Occupation phase. Pollen of olive and plane tree can be found somewhat later in the record. The area was probably not suitable for these species because of the soil and/or the hydrological conditions. The increase in deciduous tree pollen indicates moister conditions after about 3400 BP (inferred date).

Conditions in the Sakarya valley changed considerably at the time represented by spectrum 14 at a depth of about 220 cm, where a second pollen zone could be established. The pollen types indicating human activity disappeared and tree pollen took over, finally amounting 95%. Pollen of pine, fir and beech will have been transported to Küçük Akgöl from the montane area to the east and south. Pollen of deciduous oak, hornbeam, elm, willow and ash were produced by stands in and outside the valley. This kind of forest is represented by the surviving remnants of the 'Süleymanlıye Disbudak' forest.

Farmers started to abandon the Sakarya valley around 2000 BP, but it was not until spectrum 19 (100 cm) that pollen of anthropogenic indicators disappeared completely. From that time on ash became very important and large wet forests, seasonally inundated, were established. It is not easy to explain this development. For some reason the area was abandoned and vegetation could regenerate. It is not likely that a change in climate was responsible for the change in exploitation and the increase of forest. If a change in climate happened it should be visible in nearby pollen diagrams also. It is also unlikely that an increase of precipitation caused the inhabitants to leave the whole area, since the river regime would only influence the lower parts.

The topmost sample of the Küçük core that produced a pollen spectrum is found at 50 cm. A surface sample from the area (see section 6, No. 34) must be somewhat younger than the top sample of the diagram. The surface sample demonstrates that today's pollen precipitation in the Küçük area is different from the precipitation at 50 cm in the core. Chronologically, this may be about 50 years ago, an estimate based upon the only radiocarbon date.

The most recent information shows a considerably higher value for pine pollen, whereas a strong decrease is visible for pollen values of the constituents of the riverine forest. Such differences point to large-scale deforestation during recent decades.

#### 7.6. Adatepe (figs 8 and 13)

##### 7.6.1. Geography

The actual sampling locality lies on the border of Akgöl (41°2'N, 30°34'E) near Adatepe, 10 km southwest of the coastal town of Karasu, at an elevation of 50 m (fig. 8). As the name Akgöl is common all over Turkey, the site will be indicated here as Adatepe.

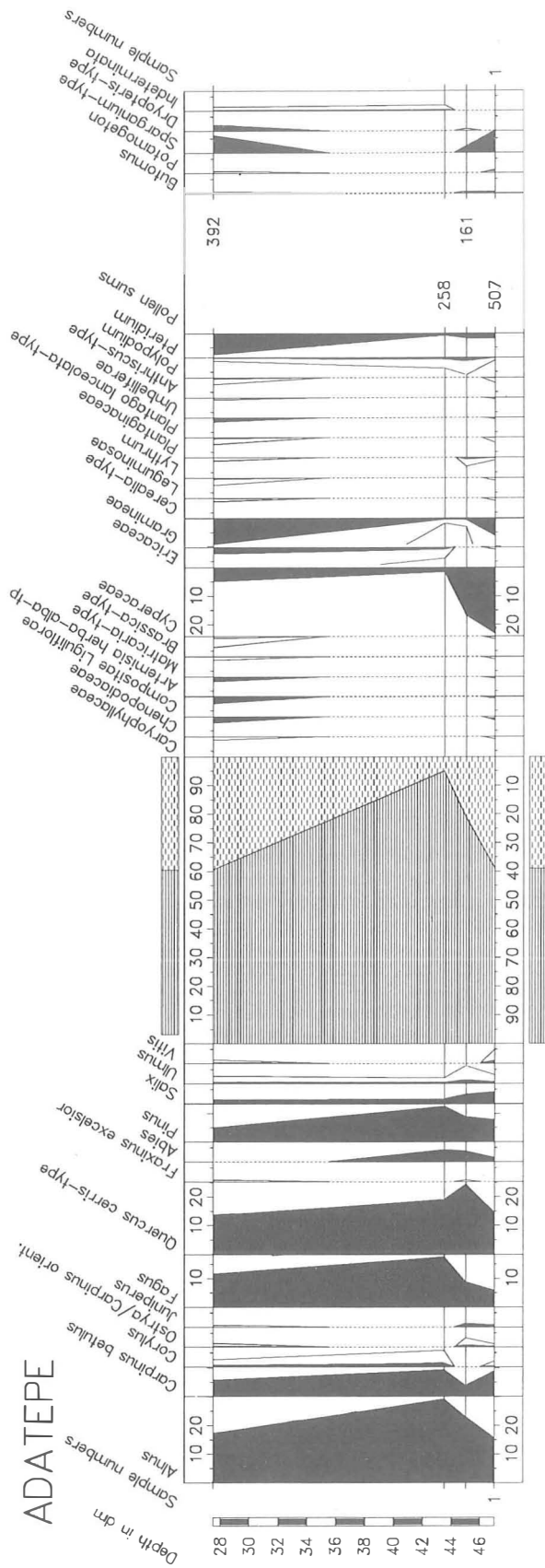


Fig. 13. Pollen diagram of Akgöl Adatepe.

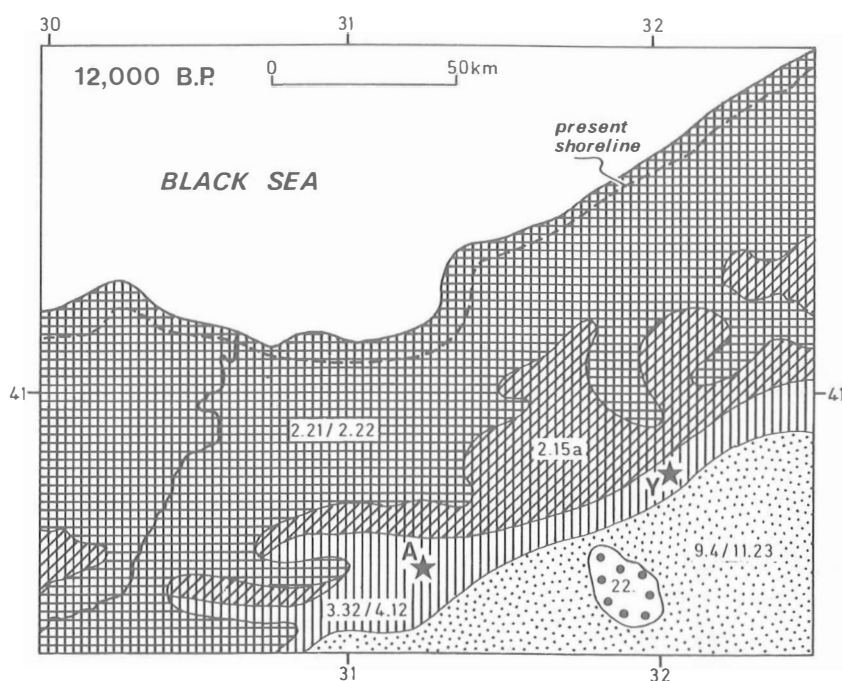


Fig. 14. Vegetation of northwestern Anatolia 12,000 BP.

Legend to figures 14-16 (after van Zeist & Bottema, 1991: p. 97):

1.32/2.22 Evergreen needle-leaved forest resistant to cold (1.32) and Cold-deciduous montane forest (2.22). Coverage: up to 100%. *Quercus*-dominated deciduous forest (in drier habitats) and *Abies nordmanniana* forest (in more humid habitats), with an upper forest belt of *Betula* sp. Between 700(800) m and 1700 m.

1.32/2.15a/2.22 Evergreen needle-leaved forest resistant to cold (1.32), Cold-deciduous montane forest with evergreen needle-leaved trees or shrubs (2.15a) and Cold-deciduous montane forest (2.22). Coverage: up to 100%. *Pinus nigra* forest (in drier habitats) and mixed *Abies nordmanniana*-*Fagus orientalis* forest (in more humid habitats). At lower elevations also deciduous forest with *Quercus* spp., *Corylus* sp., *Ulmus* sp., and *Carpinus orientalis*. Between 1000 m and 2000(2200) m.

2.15 Cold-deciduous montane forest with evergreen needle-leaved trees or shrubs. a. Mixed *Abies nordmanniana*-*Fagus orientalis* forest. Coverage: up to 100%; b. Xeric forest with *Quercus* sp., *Juniperus (excelsa)* and *Pinus (nigra, sylvestris)*. Coverage: 50-80%.

2.21/2.22 Cold-deciduous lowland forest (2.21), at higher elevations merging into Cold-deciduous montane forest (2.22). Coverage: up to 100%. Characteristic taxa: *Fagus orientalis*, *Corylus colurna*, *Carpinus betulus*, *Carpinus orientalis*, *Ostrya carpinifolia*, *Castanea sativa*, *Quercus* spp. Between sea-level and 700 m to 1000 m, upper limit depending on the temperature conditions in the period concerned.

3.32/4.12 Evergreen needle-leaved woodland relatively resistant to cold (3.32) and Cold-deciduous montane woodland with evergreens (4.12). Coverage: up to 50%. *Quercus-Juniperus* woodland (in drier habitats) and coniferous woodland dominated by *Abies nordmanniana* (in more humid habitats). Between 700(800) m and 1700 m.

4.12 Cold-deciduous montane woodland with evergreens. Coverage: up to 50%. *Quercus-Juniperus* woodland.

9.4/11.23 Mixed formation of Xeromorphic dwarf-shrublands (9.4) and Grassland rich in forbs, without trees etc. (11.23). Coverage: 10-40%. *Artemisia (herba-alba)*-dominated steppe vegetation.

22. Plant formations of the subalpine region. Coverage: unknown. Tragacanth dwarf-shrub vegetation. Above 1700 m (12,000 and 10,000 BP) and 2000(2200) m (6000 BP).

The landscape around Adatepe is dominated by the stream valley and the delta of the Sakarya river. The lake is surrounded by low hills which according to Erol (1983) are remnants of coastal terraces and other forms of Plio-Quaternary origin. A sandy strip 4-6 km wide and stretching 40-50 km along the Black Sea has been deposited by the Sakarya river.

#### 7.6.2. Climate

For the climatical conditions of the area around Adatepe, information can be obtained from sections 7.2.2 and 7.4.2.

#### 7.6.3. Present vegetation

The vegetation in the area is predominantly anthropogenic: grazed grassland and planted poplar along the roads. According to Quézel & Barbéro (1985) a Quercion ilicis with an admixture of *Quercus infectoria* and *Q. macrolepis* would be the natural forest vegetation in this part. For a more detailed description of the vegetation, see 7.4.3.

#### 7.6.4. The coring

The core was taken from a marshy meadow at the shore of the lake.

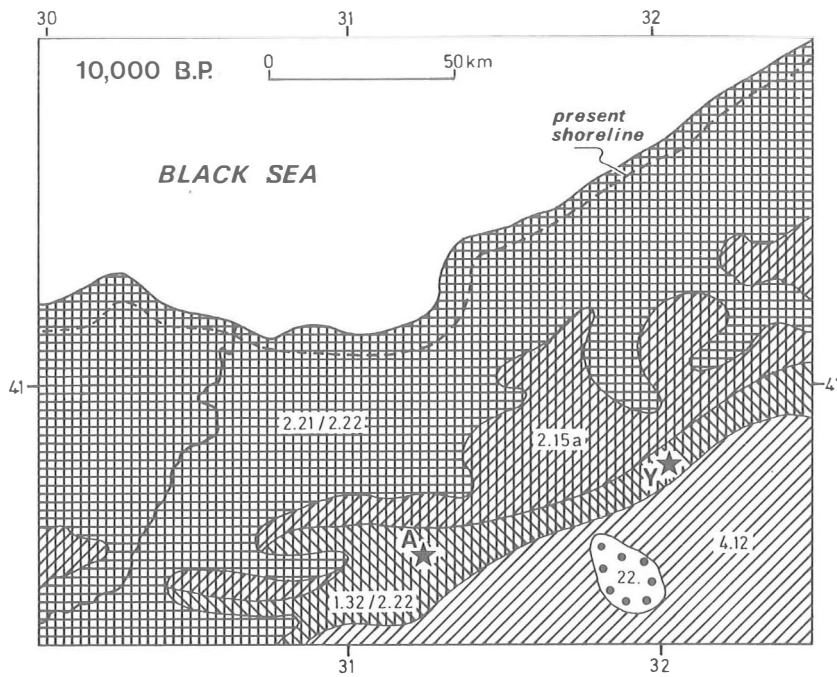


Fig. 15. Vegetation of northwestern Anatolia, 10,000 BP.

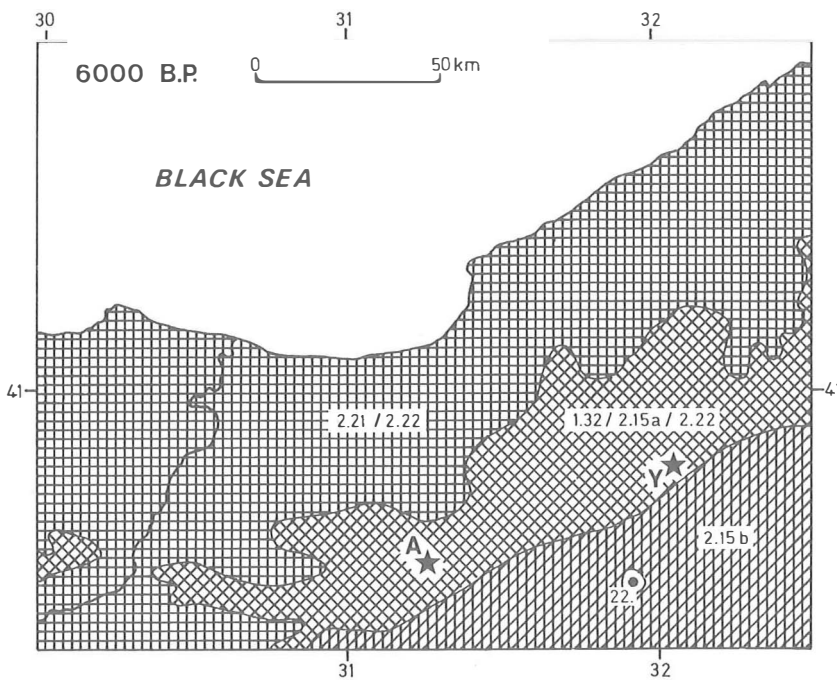


Fig. 16. Vegetation of northwestern Anatolia, 6000 BP.

#### 7.6.5. Lithology

0- 25 cm	mottled clay with recent roots	163-226 cm	brown grey gyttja-like matter with organic remains
25-115 cm	grey clay with roots	226-260 cm	grey-blue clay with fine shell fragments
115-126 cm	soft grey clay	260-310 cm	blue clay
126-155 cm	brown watery gyttja with shell fragments	310-425 cm	gyttja or clay gyttja with shell fragments
155-163 cm	grey clay		

Table 2. Pollen counts of Akgöl Adatepe.

Depth in cm	470	450	435	275	Depth in cm	470	450	435	275
Pollen sums	497	156	254	362	<i>Senecio</i> -type	—	—	—	0.8
AP	62.2	81.4	96.5	65.5	<i>Brassica</i> -type	0.2	—	—	0.8
NAP	37.8	18.6	3.5	34.5	Cyperaceae	23.5	17.3	1.6	5.2
<i>Alnus</i>	15.9	23.7	29.5	18.5	Ericaceae	0.2	—	0.8	2.5
<i>Betula</i>	0.2	—	—	—	Gramineae	6.4	0.6	0.4	9.9
<i>Carpinus betulus</i>	8.9	3.8	9.4	6.1	<i>Hordeum/Triticum</i>	—	—	—	0.3
<i>Corylus</i>	0.4	—	1.2	0.6	Cereal-type	0.2	—	—	0.3
<i>Ostrya/Carpinus orientalis</i>	0.2	0.6	—	0.3	<i>Hypericum perforatum</i> -type	0.2	—	—	—
<i>Juniperus</i>	0.6	1.3	—	0.8	Leguminosae	0.2	—	—	0.6
<i>Rhododendron</i>	—	—	—	0.6	<i>Lythrum</i>	0.2	0.6	—	0.3
<i>Castanea</i>	—	—	—	0.3	Plantaginaceae	0.4	—	—	0.6
<i>Fagus</i>	5.8	9.0	17.7	12.4	<i>Plantago lanceolata</i> -type	0.6	—	—	1.7
<i>Quercus cerris</i> -type	14.7	25.0	19.3	14.4	<i>Plantago major</i> -type	—	—	—	0.3
<i>Juglans</i>	—	—	—	2.5	<i>Polygonum aviculare</i> -type	0.2	—	—	—
<i>Fraxinus excelsior</i>	—	0.6	—	0.8	<i>Polygonum persicaria</i> -type	0.2	—	—	—
<i>Fraxinus ornus</i>	0.2	—	—	—	<i>Thalictrum</i>	—	—	0.4	—
<i>Phillyrea angustifolia</i>	—	—	—	0.8	Rosaceae	0.2	—	—	—
<i>Abies</i>	1.4	3.8	4.3	—	<i>Sanguisorba minor/Poterium</i>	—	—	—	0.3
<i>Pinus</i>	7.8	9.0	12.6	5.2	<i>Potentilla</i> -type	0.2	—	—	—
<i>Prunus</i> -type	—	—	0.4	—	<i>Galium</i> -type	0.4	—	—	—
<i>Salix</i>	4.2	3.2	1.6	1.4	<i>Melanpyrum</i>	—	—	—	0.3
<i>Tilia</i>	0.2	—	—	—	Umbelliferae	0.6	—	—	0.8
<i>Ulmus</i>	0.6	1.3	0.4	0.6	<i>Anthriscus</i> -type	0.4	—	—	0.6
<i>Vitis</i>	1.0	—	—	0.3	<i>Bium</i> -type	—	—	—	0.6
Caryophyllaceae	0.2	—	—	0.3	<i>Butomus</i>	0.6	0.6	—	0.6
Chenopodiaceae	1.4	—	—	2.5	<i>Nymphaea</i>	—	0.6	—	—
<i>Helianthemum</i>	—	—	0.4	—	<i>Potamogeton</i>	1.0	—	—	0.8
Compositae Liguliflorae	0.8	—	—	2.8	<i>Myriophyllum spicatum/verticillatum</i>	0.2	—	—	—
Compositae Tubuliflorae	—	—	—	—	<i>Sparganium</i> -type	6.8	1.9	—	6.6
<i>Centaurea solstitialis</i> -type	—	—	—	0.3	<i>Pteridium</i>	1.8	1.9	0.8	8.0
<i>Artemisia herba-alba</i> -type	0.8	—	—	1.9	<i>Dryopteris</i> -type	—	0.6	—	2.2
<i>Artemisia vulgaris</i> -type	—	—	—	0.8	<i>Polypodium</i>	0.2	1.3	0.8	0.3
<i>Matricaria</i> -type	0.2	—	—	0.3	<i>Salvinia</i>	1.4	—	—	—
					<i>Pediastrum boryanum</i>	—	—	—	0.3
					Indeterminata	—	—	0.4	0.3

425-465 cm sand  
 465-555 cm blue clay  
 555-581 cm blue clay, gradually becoming  
 mottled, with stones

#### 7.6.6. Radiocarbon dating

GrN-12795 214-219 cm 415±50 BP

#### 7.6.7. Pollen assemblage zones

Because of the absence of pollen in many parts of the core and the short time span represented by the material, the four spectra which were analyzed are shown in table 2. They can be regarded as a single pollen zone.

#### 7.6.8. Discussion

Table 2 shows the results of the analysis of the core taken from Akgöl near Adatepe. The date of 415±50 for

the level of 214-219 cm gives an indication of the age of the deepest sample at 470 cm. Assuming a constant sedimentation rate the lowest sediment will be about 900 years old.

The contents of the Adatepe record are dominated by arboreal pollen. *Alnus*, *Salix* and sparse grains of *Fraxinus excelsior* were very probably produced by the riverine forest and trees from the border of the swamps. A little drier, but experiencing floods from time to time were stands of *Quercus* (deciduous), *Ulmus* and *Carpinus betulus*. *Fagus*, *Abies* and *Pinus* pollen must have been blown in from the mountains, to the south and east of the area.

In spectrum 1 at 470 cm, pollen from local marsh plants, for instance Cyperaceae, is abundant. This depresses the total tree pollen percentage to a very low value. The values of the non-marsh components of the pollen record of samples 1-3 are more or less the same. They represent the period from about AD 1000 to 1100. Pollen types that indicate farming, whether crop

cultivation or grazing, have very low scores. Quite probably not much farming activity occurred in the delta of the Sakarya river.

About 500 years ago, around AD 1500 (spectrum 4 at a depth of 275 cm) tree pollen values were lower. Local riverine forest and trees of the valley show lower pollen values. A large diversity of herb pollen types points to an increase in open space. The mountain forest far away must have suffered from human exploitation. *Abies* has disappeared completely from the pollen spectrum; *Fagus* and *Pinus* have decreased.

If we compare the upper parts of the pollen diagrams of Küçük Akgöl and Adatepe, the latter seems to represent the most recent years. Values found in the Adatepe record are not matched by comparable ones in Küçük Akgöl, which suggests that the corresponding section is absent.

## 7.7. Seyfe Gölü (figs 8 and 17)

### 7.7.1. Geography

Seyfe Gölü (39°12'N, 34°24'E) lies c. 20 km east-northeast of the town of Kırşehir, at an altitude of 1080 m (fig. 8). The very shallow lake lies in a large plain. Most of the surrounding mountains are far away, except

for a ridge (1692 m) that separates Seyfe Gölü from the Kırşehir area. The plain is covered with clay and gravel of unknown origin. The east shore is formed by erosion which has resulted in steep sides that seem to be dangerous to walk along. The lake must be deeper along this side and the bank could be eroded by waves. North of the lake no river beds were found and extensive *Salicornia* vegetation dominated the scenery. The west side of Seyfe Gölü was reached by the road to Karacaören. At about 1 km north of the coring locality a large prehistoric mound (tell) is found.

Outcrops of the western mountains almost reach the water. In the lake basin, bordering the main waterbody, small lakes with stagnant water with a lot of waterplants are found behind sand bars formed by wave action. The depth of the lake could be estimated by watching foraging flamingos which stood in the water up to their hocks more than 500 m from the shore.

### 7.7.2. Climate

The forest-steppe climate of the Central Anatolia is characterized by an average January temperature of +1 to -3°C and 20-23°C for July. Annual precipitation ranges from 280-440 mm, of which the most falls in winter and spring.

## SEYFE GÖLÜ

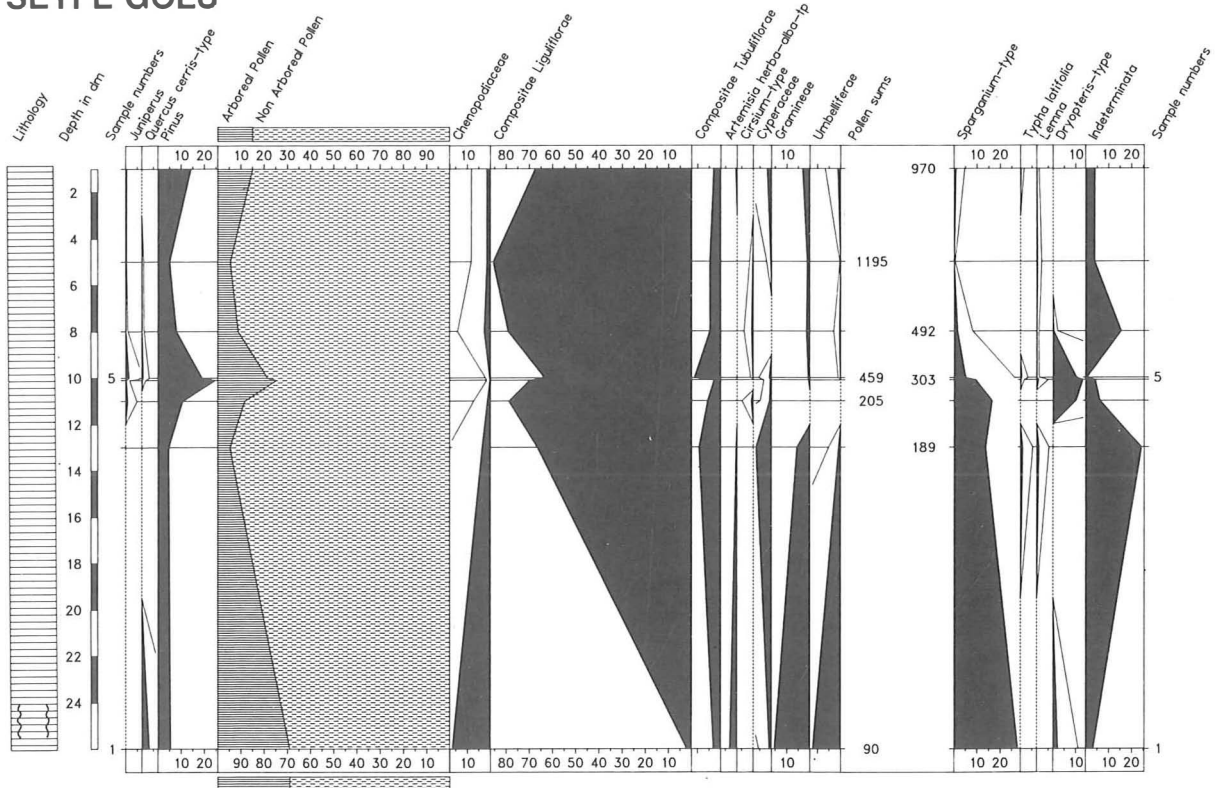


Fig. 17. Pollen diagram of Seyfe Gölü.

### 7.7.3. Present vegetation

The vegetation zone in which Seyfe Gölü is situated lies below the lower steppe-forest line, at 1200-1300 m for Kırşehir according to Mayer & Aksoy (1986), from which also the following information is derived. For the central region (Ankara) the upper tree line is at 2200 m. The tree line in the Seyfe region can hardly be estimated on the basis of the present-day distribution of remnants of steppe-forest, because of the pronounced human impact. The actual tree cover, including degraded scrub, is about 7% of the cover that was present in central Anatolia before the action of man. Most of the steppe was dominated by *Quercus pubescens* and *Pyrus elaeagnifolia*. At the edges of the central plain some *Pinus nigra* is still found. In the case of exploitation, *Quercus pubescens* regenerates faster than *Pinus nigra*.

The coring locality lies in a grazed meadow with tussocks of *Juncus acuta* and abundantly flowering *Carex*. On the wetter parts *Scirpus* could be seen and on saline soil bordering the water, tussocks of *Juncus acutus*. The area around the coring locality, as well as the lakeside and the mountains around the lake, is devoid of trees.

### 7.7.4. The coring

The core was taken not far from the village of Gümüstümbet Köyü (39°12'N, 34°23'E).

### 7.7.5. Lithology

5- 25 cm	dark clay
25-105 cm	light grey clay, sometimes marly
105-120 cm	dark grey clay
120-130 cm	grey clay
130-140 cm	white, hard marl
140-231 cm	light green marly clay with occasional dark spots
231-236 cm	light blue marly clay
236-248 cm	white-grey clay, a little sandy
248-259 cm	as above, with some <i>Phragmites?</i> roots
259-274 cm	white-green clay with dark patches
274-303 cm	green clay, with some black roots and concretions
303-311 cm	grey clay with concretions
311-400 cm	blue clay with some roots
400-415 cm	white clay
415-425 cm	no recovery
425-464 cm	yellow-brown to white-brown marly clay

Further coring was impossible because of hard sediment.

### 7.7.6. Radiocarbon dates

The sediment could not be dated because it lacked organic deposits.

### 7.7.7. Discussion

Because of the low pollen concentration and poor preservation, only 7 spectra in the upper 120 cm were analyzed. They are treated as one pollen zone. In the lower spectra only low pollen sums could be realized but in the upper samples more than 1000 pollen grains were counted. It is supposed that the lower part, which did not contain any pollen, dried up during the summers while new sediment was added during the winter. Such a regime is thought to cause the oxidation of organic material.

The Seyfe diagram is characterized by high values of Liguliflorae (70-80%). Tree pollen is represented by *Pinus*, averaging about 10%. Very rarely *Juniperus* and *Quercus* are encountered. Except the abundant Liguliflorae, a few percent of Chenopodiaceae, Tubuliflorae, *Cirsium*-type, Cyperaceae, Gramineae and Umbelliferae are found. In the lower part of the diagram *Sparganium*-type has important values, followed by 10% of *Dryopteris*.

The pollen record of Seyfe Gölü is not very informative about former vegetations. The high Liguliflorae values are an important feature that points to the special sedimentary conditions in this part of Turkey (see also section 7.8)

## 7.8. Tuzla Gölü (figs 8 and 18)

### 7.8.1. Geography

The saline Tuzla Gölü (39°2'N, 35°49'E) is found c. 900 m above sea level at the north side of the road from Kayseri to Sivas, at c. 45 km from Kayseri (fig. 8). The lake lies in a shallow basin surrounded by low hills and is bordered in the northwest by fairly steep, 1500 m high, mountains which separate it from the Kızılırmak river. The lake contracts considerably during the summer as a result of evaporation. Most of the area around the lake consists of flats of red gravel, especially in the north. The groundwater table in the area is high, according to Erol (1983).

### 7.8.2. Climate

For a description of the climate, see section 7.7.2.

### 7.8.3. Present vegetation

The vegetation near the coring location includes *Puccinellia*, *Sonchus* and *Spergularia* cf. *maritima*. On low hillocks grazed by cattle, *Trifolium*, Gramineae, *Sonchus*, *Cirsium*, *Centaurea*, *Juncus* (not *acutus*), *Cichorium*, *Carex* cf. *ovalis* and yellow-flowering Cruciferae were found. Around stagnant pools at the edge of the lake *Scirpus* cf. *maritimus*, *S. palustris*, *Anagallis aquatica*, *Carex*, *Orchis* and *Plantago* were observed.





#### 7.8.4. The coring

The core was taken at the west side of the lake near Çavlak. The site was chosen because no disturbance of the sediment by small discharging streams was observed, as was the case in many other places.

#### 7.8.5. Lithology

0- 60 cm	grey clay, brown spot in lower 6 cm
60-113 cm	light-coloured clay with brown spots, some gravel and rootlets in lower part
113-152 cm	light blue clay with a thin gravel layer at 147 cm
152-239 cm	blue-grey clay
239-284 cm	grey clay sometimes with white spots
284-317 cm	blue-grey clay with sand
317-345 cm	grey clay
345-381 cm	white-green spotted clay, sometimes with concretions

At this depth a hard layer was hit that made further coring impossible.

#### 7.8.6. Radiocarbon dating

No datable material was found.

#### 7.8.7. Pollen assemblage zones

Zone 1 (spectra 1-3): relatively high AP values, *Pinus* and *Quercus*. Herb-pollen types are *Artemisia* and *Chenopodiaceae*.

Zone 2 (spectra 4-9): lower AP percentages, NAP mainly *Liguliflorae*. In spectra 4-7 (subzone 2a) *Chenopodiaceae* attain up to 30%, but in subzone 2b (spectra 8-9) they have disappeared and *Pinus* values have increased to 30-50%.

Zone 3 (spectra 10-16) is characterized by AP values of up to 60%, mostly *Pinus*. Herb pollen values have decreased owing to a fall in *Liguliflorae*.

#### 7.8.8. Discussion

The record of Tuzla Gölü represents the pollen precipitation of the vegetation of the central Anatolian steppe, but the composition of that precipitation certainly underwent changes through various agents. The spectra could be explained simply by assuming that taxa which produced pollen found in the sediment, represented the vegetation growing around the lake. From the surface-sample study (section 6) we obtained information on the composition of the present-day pollen precipitation in the central part of Anatolia. Information on the local vegetation obtained from our field notes and from literature shows that no pine occurs in the area, and that high *Pinus* pollen values are an over-representation caused by a combination of factors

such as low local pollen production and easy pine pollen transport from stands in the mountains, further away.

The high values for the *Liguliflorae* need a different explanation. Yellow-flowering composites producing this pollen type are insect-pollinated and the numbers of pollen grains in the diagram (up to 60%) are not matched by counterparts in the modern vegetation. The latter shows maxima of 1.5%, even where abundant flowering of such composites was witnessed. Thus, the presence of high *Liguliflorae* pollen percentages in the diagram cannot be explained by a dominance of these plants in the vegetation, because even where these plants occur they do not produce such high pollen percentages.

Anomalous high values for *Liguliflorae* are explained by Bottema (1975) and Bottema & Woldring (1990). At Tuzla their presence may have been caused by a combination of factors. Exceptionally high values can be caused by selective corrosion and selective identifiability of a particular type. *Liguliflorae* fulfil these demands. Over-representation could also have been stimulated by the concentration in a lake of pollen from summer-flowering composites from hot plains (Bottema & Woldring, 1984(1986); 1990). Thus the presence of large numbers of *Liguliflorae* reveals more about certain edaphic conditions than about subfossil vegetation. The effect of summer drought may have a climatical cause, but may also be a feature of a sedimentary stage, the infilling of the basin.

The pollen scores of the Tuzla core are information that lead us to the following conclusions. In zone 1, the spectra are reasonably rich in pollen, indicating that a moist phase occurred after a relatively dry one that had formed the hard layer at 381 cm. During the moister phase, pollen of various tree types precipitated in the lake, including some *Alnus*, *Betula*, *Corylus*, *Ostrya*, *Juniperus*, *Abies* and *Cedrus*. *Quercus* values are even up to 15% and *Pinus* pollen measures 30-40%. Although the tree pollen may be due to long-distance transport in a treeless area, it still reflects a period during which tree growth was favoured somewhere. Still one has to keep in mind that the appearance of types in the record does not imply that they were not there before but in the first place that from that time on the pollen was preserved.

The non-arboreal types in zone 1 show lower values than in the subsequent zone 2, but they display a greater diversity in types, including *Caryophyllaceae*, *Ranunculaceae* and *Rosaceae*.

Zone 2 is characterized by the dominance of *Liguliflorae* and much lower pollen sums. It is obvious that something happened around Lake Tuzla. Very probably the sediment dried up from time to time if not every summer. This caused partial oxidation and over-representation of the pollen of the yellow-flowering composites. *Gramineae* and *Artemisia* pollen, as well as that of deciduous trees, is lacking. *Chenopodiaceae* (goose-foot family), a typical taxon for open vegetation with saline or gypsum-rich soils, only play a role during

the early part of zone 2. The appearance of pollen of the goose-foot family in surface samples of the central-Anatolian steppe is clearly connected with the edges of saline lakes. Also in the Tuzla Gölü subfossil record this taxon may have become abundant from the moment when evaporation began to play a role, to be outnumbered by Liguliflorae somewhat later.

Towards the end of zone 2 an increase of pine pollen is visible. In the upper zone conditions as found before, in zone 1, return. *Pinus*-pollen values are even higher but the other trees are less well represented. Herbs display more or less the same values as in zone 1. Those of *Artemisia*, a representative of steppe vegetation, are much lower. Local conditions must have changed during the deposition of the upper part of this zone, as is indicated by an increase of the pollen of Cyperaceae from 10 to 38%. This suggests that the lake turned into a marsh.

*Pinus* values decrease in the upper part of the diagram. This may be an indication of recent human activity. Representatives of the State Forestry Department at Sivas and Kırşehir mentioned that in some parts of the area extensive *Pinus nigra* forest still occurred some 30-40 years ago. This must have been in the higher parts similar to those localities where *Pinus nigra* is still found (Quézel & Barbéro, 1985). *Pinus* pollen may partly originate from *Pinus sylvestris* growing on the eastern Taurus mountains (Mayer & Aksoy, 1986).

No radiocarbon dates are available and so an attempt will be made to date the diagram by cross-correlation with nearby radiocarbon-dated diagrams. The nearest diagrams for correlation are from Kaz Gölü and Lâdik Gölü. In Kaz Gölü, the increase of deciduous tree types (zone 3) is dated  $2220 \pm 90$  BP. At the same time *Pinus* pollen decreases. In Lâdik Gölü the increase in deciduous pollen is dated  $2760 \pm 50$  BP; 30 cm deeper a date of  $4280 \pm 80$  BP is found. In the Pisidian district the pollen assemblage of the Beyşehir Occupation phase, very likely the same event, is dated about 3200 BP. The Kaz Gölü and Lâdik dates seem to be too young. In the case of the latter this seems to be supported by the much older date found 30 cm lower. Comparison of the Tuzla record with this information points to a possible age of about 3000 BP or somewhat younger for the lowest spectrum, 1, at a depth of 380 cm.

## 7.9. Demiryurt Gölü (figs 8 and 19)

### 7.9.1. Geography

Demiryurt Gölü (39°44'N, 37°23'E) is found 55 km east of Sivas at an elevation of 1300 m in the stream valley of the Kızılırmak, between the small towns of Hafik and Zara (fig. 8). The lake drains to the west in a small stream which discharges into the Kızılırmak river, 10 km to the west near the village of Yarhisar.

### 7.9.2. Climate

The area around Demiryurt Gölü is part of a region which has a rather cold and dry climate compared to other parts of the area under study. Annual precipitation is less than 600 mm.

### 7.9.3. Vegetation

A low and flat area extends locally from the Sivas to Zara road to the lake of Demiryurt. In the wet and marshy part this area carries little vegetation but in drier parts a dense cover of Cruciferae is found, while Plumbaginaceae are also frequent. The lake itself has a fringe of *Phragmites australis* and *Scirpus lacustris*.

### 7.9.4. The coring

A core was taken at the edge of the lake, on the landward side, outside the *Phragmites* belt. Because the water was clear, many small tussock-like structures could be seen creating an undulating bottom. At Akgöl (Konya Plain) such small tussocks were observed in a marsh that had dried up during the dry season.

### 7.9.5.

#### Lithology

0- 10 cm	yellow-brown clay
10- 12 cm	dark band
12- 35 cm	grey-white calcareous clay
35- 45 cm	grey-brown calcareous clay
45- 80 cm	grey-white clay, sometimes sandy
80- 83 cm	pale blue clay
83- 88 cm	brown clay
88-122 cm	grey-blue clay
122-131 cm	black-brown organic clay
131-136 cm	brown clay
136-147 cm	blue-and-yellow clay
147-150 cm	brown clay with rootlets
150-179 cm	brown-grey clay
179-221 cm	pale blue clay
221-251 cm	peat or peaty gyttja
251-305 cm	very soft blue clay
305-325 cm	no recovery
325-338 cm	blue-grey clay
338-350 cm	peat
350-405 cm	pale blue-grey clay with remnants of monocotyles in the upper part
405-411 cm	white sand

Further coring turned out to be impossible.

### 7.9.6. Radiocarbon dating

GrN-12792	337-344 cm	1940 $\pm$ 60 BP
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### 7.9.7. Pollen assemblage zones

Percentages in the Demiryurt diagram are calculated on the basis of a pollen sum including tree pollen and

upland herb types. Because of their very irregular patterns Chenopodiaceae, *Senecio*-type, Cyperaceae and Gramineae are left out of the basic sum.

Zone 1 (spectra 1-7): relatively low AP values, high values of *Artemisia* and *Sanguisorba minor*/*Poterium*. *Fagus* is well represented, except in spectrum 3.

Zone 2 (spectra 8-9): tree pollen amounts to c. 95% in spectrum 8, mainly consisting of *Pinus*. *Fagus* pollen values drop from 10% in zone 1 to less than 1% in zone 2.

Zone 3 (spectra 10-13) has lower AP values, c. 60%. Various herb pollen types, including Compositae, *Polygonum aviculare*-type, Cerealia-type and *Sanguisorba minor*/*Poterium*-type, show high values.

Zone 4 (spectra 14-15): AP values, mainly *Pinus*, are important again. *Quercus* and *Fagus* have increased in comparison with the preceding zone.

Zone 5 (spectra 16-17): lower AP values and an increase of the herb pollen types mentioned in zone 3.

Zone 6 (spectra 18-23): high values of AP, exclusively represented by *Pinus*, characterize this zone.

#### 7.9.8. Discussion

Palynological information from the Demiryurt area is based upon the core from the lake and a surface sample collected near the lake (No. 8).

The topmost spectrum of the diagram (23) very probably represents the actual pollen precipitation from the area around the lake and the edge of the lake. Surface sample No. 8 also includes the local pollen precipitation, such as Plumbaginaceae, Chenopodiaceae and Cruciferae. The share of *Pinus* in the pollen rain of surface sample No. 8 amounts to 23%, whereas this type makes up almost 80% in the top spectrum of the diagram. The conspicuously high values of *Pinus* in the upper samples of Turkish pollen cores are discussed in section 8.

The behaviour of *Pinus* is one of the most characteristic features of the diagram. There is a clear correlation between the proportion of this conifer type and the arboreal pollen sum. Still, low values of *Pistacia*, *Fagus*, *Olea* and *Abies* draw the attention because they are only found in part of the diagram.

Zone 7 shows relatively low *Pinus* values, 40% on average. *Pistacia*, *Fagus* and *Abies* are present especially during spectra 4-8, possibly demonstrating the regeneration of natural vegetation in the area. At the same time there is not much difference in the values of primary or secondary anthropogenic indicators such as Cerealia-type, *Rumex*, *Plantago lanceolata* and *Sanguisorba minor*-type. The pollen assemblages could point to a continuous pressure upon the stream valley of the Kızılırmak, whereas some regeneration took place at higher levels in the mountains from time to time.

The various pollen zones can be dated by interpolation from the  $^{14}\text{C}$  date of  $1940 \pm 60$  BP at 337-344 cm. This would date the boundary between zone 1 and zone 2 at 1370 BP. Calibrated this would be about AD 650.

From this point on an increase in *Pinus* pollen values can be seen. These high values of pine are also recorded at present. It does not mean that after AD 650 a period dominated by pine occurred. Primarily the spectra display very high *Pinus* pollen values, even those representing modern times. Yet the abundance of pine pollen is not reflected by the actual vegetation. The high pine values may result from a very low pollen production of the remaining components of the vegetation. It may be postulated that the effect of the exploitation of the landscape in the area of Demiryurt became visible around AD 650 and that the landscape has not changed significantly since that time. Some oscillations can be observed. Pollen zones 3 and 5 display lower *Pinus* values than zones 4 and 6 and one may wonder if there is a local or regional cause for these fluctuations.

The zones with lower AP values are characterized by lower pine counts and higher percentages of Caryophyllaceae, various composites, Cerealia-type, *Plantago* types, *Sanguisorba minor*-type, *Galium*-type and Umbelliferae. Some of these types are still common in the present-day pollen rain, as is shown in surface sample No. 8. The lowering of the AP values may have been caused by an increase of human activity in the area.

The pollen zones created for the Demiryurt core were not easy to define. The choice is either to emphasize the AP lows or the NAP highs. The first option, a zonation based upon low AP phases, reduces the remaining parts to single spectra with high AP values. If the AP highs are chosen as to define zones, separated by stretches of low AP values, these zones number only one or two spectra. At the same time there are pollen types that do not correlate either in a positive or negative way with other types or groups of types. This makes the identification of zones difficult. The main feature of zones 4 and 5 is the appearance or increase of some tree types after a period that carries signs of human activity (zone 3). Zones 4 and 5 differ in pine-pollen values, but the behaviour of *Alnus*, *Betula*, *Carpinus betulus*, *Corylus*, *Juniperus*, *Fagus*, *Quercus*, *Abies* and *Picea* is not significantly different. This assemblage of tree species can be explained in several ways. A notable fact is that their values are low enough to have been caused by long-distance transport, especially for those types that do not grow in the area, e.g. *Betula* and *Picea*. A pollen grain of *Picea* in the present-day pollen precipitation of surface sample No. 8 very probably arrived from stands east of 38°E, the nearest *Picea orientalis* growing at a distance of about 50 km.

According to the New Turkish Atlas (*Yeni Türkiye Atlasi*, 1977), the wind in the Hafik area predominantly blows from a northerly direction at any time of the year, thus coming across the Black Sea. *Betula* pollen may have been carried in from the north, over the sea, whereas *Picea* may have been carried in from the east.

The oldest part in this diagram, recording various tree types, dates from c. 2000 to 1370 BP. The top section, with a comparable content, dates from c. 700 to

## BÜYÜK GÖLÜ

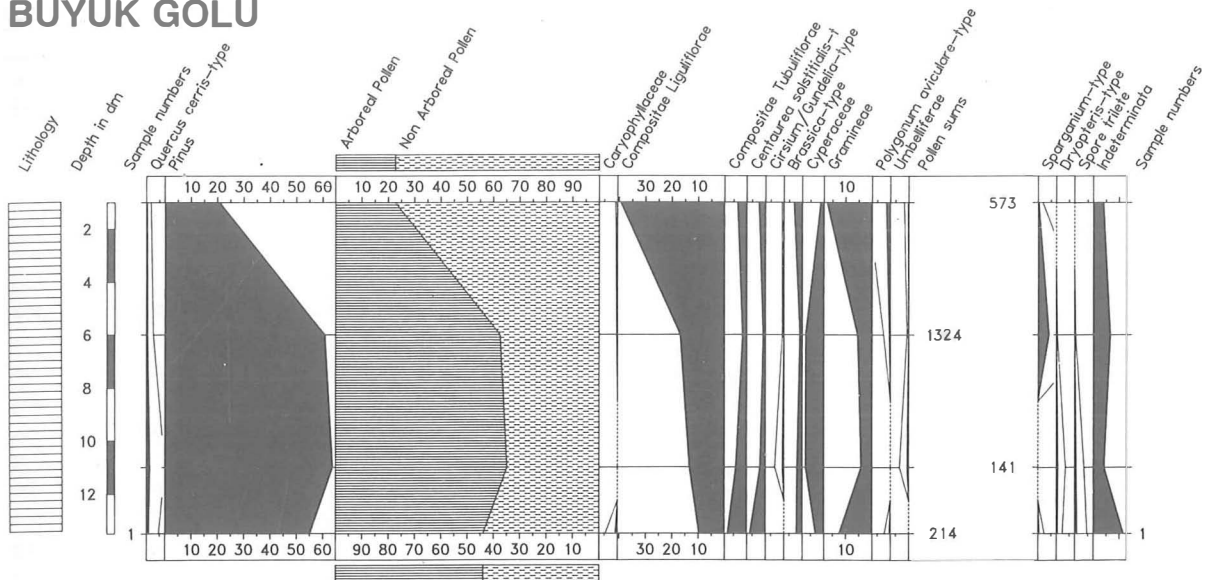


Fig. 20. Pollen diagram of Büyük Gölü.

450 BP (AD 1290-1440) (interpolated dates based on one  $^{14}\text{C}$  sample).

## 7.10. Büyük Gölü (figs 8 and 20)

### 7.10.1. Geography

The small lake of Büyük Gölü (39°52'N, 37°23'E) lies 20km west of Demiryurt Gölü and east of Sivas near the town of Hafik, at an elevation of 1300 m (fig. 8). Büyük Gölü may be the result of combined karstic and tectonic action. The small lake lies in the Kızılırmak valley in an area which drains towards the Kızılırmak river. This drainage seems to have formed a karstic depression, partly bordered by large boulders with depressions in between. The run-off apparently was partly blocked, which gave rise to a small lake.

### 7.10.2. Climate

See Demiryurt (7.9.2).

### 7.10.3. Vegetation

The surroundings of Büyük Gölü are completely cultivated and crops and weeds form the only vegetation. Ploughed fields around the lake abound in *Centaurea solstitialis* and *Arum* spec.

### 7.10.4. The coring

Coring was performed at the edge of the lake, in the margin of a ploughed field.

### 7.10.5. Lithology

5- 70 cm ochre-coloured sticky clay, upper part with recent roots

70-145 cm ochre-and-black clay with lime concretions

Further coring turned out to be impossible.

### 7.10.6. Radiocarbon dates

No radiocarbon dates are available.

### 7.10.7. Pollen assemblage zones

No pollen zones were identified because of the small number of spectra.

### 7.10.8. Discussion

Of the 37 pollen types identified in the samples from Büyük Gölü (table 3), 16 types were frequent enough to be included in a short diagram. Only four spectra were counted and it became clear that the sediment of Büyük Gölü covered a recent period only. The number of pollen types per sample decreases with depth, a feature in sediments that have been oxidized or are still subject to such a process.

The reason for sampling the colluvial deposit of Büyük Gölü was to study the representation of pollen of weeds originating from the arable land and brought down by slope wash. The flowering *Centaurea solstitialis* was particularly prominent in the landscape. Of course its presence during our field work in 1984 is no proof that this species was abundant during the whole

Table 3. Pollen counts of Büyük Gölü.

Depth in cm	135	110	60	10
Pollen sums	204	141	1379	645
AP	58.8	65.2	63.6	20.2
NAP	41.2	34.8	36.4	79.8
<i>Alnus</i>	—	—	0.1	0.2
<i>Betula</i>	—	—	—	0.2
<i>Carpinus betulus</i>	—	—	—	0.2
<i>Juniperus</i>	—	—	0.8	0.2
<i>Corylus</i>	—	—	0.1	—
<i>Fagus</i>	—	—	0.1	0.3
<i>Quercus cerris</i> -type	1.0	1.4	0.5	0.3
<i>Pinus</i>	57.8	63.8	61.9	18.6
<i>Daphne</i>	—	—	—	0.3
Caryophyllaceae	1.0	—	0.1	0.6
Chenopodiaceae	—	—	0.1	2.0
Compositae Liguliflorae	10.3	13.5	16.2	35.2
Compositae Tubuliflorae	7.8	4.3	1.6	3.3
<i>Artemisia herba-alba</i> -type	—	—	0.7	1.7
<i>Centaurea cyanus</i> -type	0.5	—	—	—
<i>Centaurea solstitialis</i> -type	6.4	2.1	0.9	2.3
<i>Cirsium/Gundelia</i> -type	—	0.7	0.1	0.3
Cruciferae	—	—	0.1	—
Brassica-type	2.5	2.1	1.0	2.9
Cyperaceae	3.4	7.1	7.2	6.2
<i>Scabiosa palaestina</i> -type	—	—	0.1	—
Gramineae	8.3	4.3	5.4	15.3
Cereal-type	—	—	0.1	2.2
Leguminosae	—	—	—	0.5
Plantaginaceae	—	—	—	0.8
<i>Plantago coronopus</i> -type	—	—	1.3	2.9
<i>Plantago lanceolata</i> -type	0.5	—	0.4	—
<i>Polygonum aviculare</i> -type	0.5	—	0.5	1.6
<i>Thalictrum</i>	—	—	—	0.2
<i>Filipendula</i>	—	—	0.1	—
<i>Galium</i> -type	—	—	—	0.3
Umbelliferae	—	0.7	0.1	1.2
<i>Turgenia</i> -type	—	—	0.2	0.3
<i>Sparganium</i> -type	0.5	0.7	2.7	1.2
<i>Butomus</i>	—	—	—	3.1
<i>Nymphaea</i>	0.5	2.1	—	—
<i>Pteridium</i>	0.5	0.7	—	—
<i>Dryopteris</i> -type	0.5	0.7	0.1	—
<i>Polypodium</i>	—	—	—	0.2
Spore trilete	1.0	0.7	0.1	0.2
Indeterminata	12.3	4.3	6.5	14.1

period represented by the Büyük record. The pollen record has a value of c. 6% for *Centaurea solstitialis*-type in the oldest spectrum 1. The values decrease to 2% in spectrum 3 and reach 4% in the top sample. Such values are very low compared with some Anatolian pollen diagrams, where values of c. 15%–40% for *C. solstitialis*-type are found. Furthermore, surface sample No. 8, taken at a distance of 20 km, shows no *Centaurea solstitialis*. The difference between the *Centaurea solstitialis* percentages in a slope-wash sediment and a lake deposit point at fundamental dissimilarity in the way this pollen type precipitates.

It was formerly thought that extremely high values of Chenopodiaceae, *Matricaria*-type or *Centaurea solstitialis*-type were caused by luxurious growth of plants belonging to these taxa on flats that became exposed after shrinking of waterbodies during the summer. Indeed, we observed abundant *Centaurea solstitialis* and *C. iberica* on the bottoms of dried-up lakes. However, such exposures were caused by man-made drainage. In such basins water would eventually collect during the winter but drainage was sufficiently organized to get rid of the water early in the spring so as to produce pasture for cattle and sheep. Under natural conditions the shrinking is more gradual and central-Anatolian lakes, such as Tuzla and Seyfe, show Juncaceae and Cyperaceae on the exposed shores and no composites. The problem is that lakes from which much water evaporates during the summer, are inclined to be brackish. It may be argued that such lakes are not suitable for the growth of *Centaurea solstitialis*. A lake shore that offers a non-saline habitat for *Centaurea solstitialis*, already dry for this plant to start the annual cycle and to flower during the summer, has to be dry early in spring. Such conditions are unlikely to occur naturally. The only remaining possibility is that of man-induced conditions, which did not yet exist during prehistoric times. The high values of *Centaurea solstitialis* are explained in a different way (Bottema & Woldring, 1990).

Four spectra of this core were analyzed, the results of which are shown in table 3. Spectrum 4 at a depth of 10 cm may be considered as a surface sample. Compared with the results of surface sample No. 8, spectrum 4 of Büyük has about the same amount of *Pinus* and Gramineae, much higher Liguliflorae and no Chenopodiaceae and Plumbaginaceae.

## 7.11. Kaz Gölü (figs 8 and 21)

### 7.11.1. Geography

Kaz Gölü (Tokat Ovası) lies in a large alluvial plain between Tokat and Zile, c. 12 km south of Turhal (40°17'N, 36°9'E) at an elevation of c. 500 m (fig. 8). The plain is drained by a stream or canal that runs from east to west to the Yeşilirmak. The Deveci mountains, south of the lake, collect water which fills the lake. To prevent flooding of the farmland around Kaz Gölü, dikes have been constructed at the lower end of the lake. At the east side such a dike borders the canal that runs parallel to the lake shore.

Kaz Gölü itself is a large marsh. It contains a lot of water, but most of the surface is covered by a floating mat. Coring through this floating mat into the lake bottom showed the presence of water at a depth of about one metre. Towards the edge of the lake this floating mat was replaced by reeds (*Phragmites australis*) and rushes (*Scirpus lacustris*) growing in deep water. The water coming from the Deveci mountains runs more or

less around the marsh to discharge into the Yeşilırmak.

The floating sedge mat was solid enough to carry cattle and it was observed how water-buffalos and Anatolian black cattle crossed the canal swimming to climb up onto the sedge mat where they grazed a quite ordinary-looking meadow.

With the help of a local fisherman who acted as a guide it was possible to row through the *Phragmites* and *Scirpus* belt to penetrate far into the marsh.

#### 7.11.2. Climate

The Kaz Gölü lies in an area with a transitional climate. In the northeast, wet and relatively cold conditions are found, which stimulate a cold-resistant woodland. In the west and southwest drier conditions favour steppe plants.

According to TAVO map A IV 4 (Alex, 1984) and measured at the station of Tokat, Kaz Gölü lies in the 600-800 mm precipitation zone. The average January temperature is in the 0-5°C zone, while the average July temperature is between 20 and 25°C (Alex, 1983b).

#### 7.11.3. Present vegetation

Kaz Gölü is found in a vegetation belt which is characterized by deciduous and evergreen needle-leaved species resistant to cold. At present the area around the lake is deforested and used as farmland. Trees or forest can be seen on the north slopes of the distant Deveci mountains south of the lake. The main road south of Kaz Gölü is bordered by arable land which towards the lake gradually changes into grazed marshland. Around the coring site on the lakeward bank of the canal, *Phragmites* and *Scirpus* grow in water of more than 1 m deep. The transition between deep-water vegetation and the floating sedge mat was very abrupt. The grazed mat was formed by grasses, sedges, *Lythrum salicaria* and other marsh plants.

#### 7.11.4. The coring

A core was taken in the narrow strip of land between the dike and the canal. Local farmers explained that clay from the canal was used to construct the dike, but that the surface of the land in between had not been changed. The coring locality was selected in a section where ploughing or other disturbance was measured to be 23 cm deep. The core was taken in two successive days.

#### 7.11.5. Lithology

23-	30 cm	mottled clay
30-	38 cm	blue-grey clay
38-	48 cm	brown clay
48-	56 cm	blue-grey clay
56-	65 cm	dark clay (disturbed?)
65-	81 cm	dark clay

81-	91 cm	marbled clay
91-	269 cm	grey to dark grey clay, sometimes with rusty patches
269-	282 cm	dark grey sandy clay
282-	338 cm	grey to grey-brown clay
338-	340 cm	grey to brown clay band with sand and gravel
340-	423 cm	light-grey clay with brown patches
423-	587 cm	blue-grey clay
587-	589 cm	blue-grey clay with some gravel, a red piece of oxidized chalk
589-	736 cm	dark grey clay
736-	750 cm	ochre clay with black patches
750-	948 cm	grey clay with black patches, which becomes more brown after c. 800 cm
948-	1025 cm	black clay
1025-	1047 cm	grey clay with white and some black patches
1047-	1079 cm	granular clay, water-bearing layer
1079-	1083 cm	light-brown clay

The coring had to be stopped because the sediment became too hard.

#### 7.11.6. Radiocarbon dates

GrN-18624	415-425 cm	2220±90 BP
GrN-12791	950-960 cm	8770±80 BP

Sample 950-965 cm was pre-treated with acid only once, because of the low organic fraction.

#### 7.11.7. Pollen assemblage zones

Zone 1 (spectra 1-11): characteristic are the very low tree pollen (AP) values, and important values for herb pollen, especially Liguliflorae, Chenopodiaceae, *Artemisia herba-alba*, Cyperaceae and Gramineae.

Zone 2 (spectra 12-26): strong increase in tree pollen caused by *Pinus*. Herb pollen is represented especially by Liguliflorae. A subdivision is made on the basis of the behaviour of some characteristic types. Subzone 2a (spectra 12-19) shows high percentages of *Pinus* and Liguliflorae, very low *Artemisia herba-alba*-type and Cyperaceae. In subzone 2b (spectra 19-26) both *Pinus* and Liguliflorae have reduced values in favour of Cyperaceae and *Artemisia herba-alba*-type which increased from 2 to 20-30%.

Zone 3 (spectra 27-36): AP values have increased and a large number of types is represented in low percentages, including *Carpinus betulus*, *Corylus*, *Ostrya/Carpinus orientalis*, *Castanea*, *Fagus*, deciduous *Quercus*, *Juglans* and *Olea*. The herb types prominent in the preceding zone have clearly decreased. *Plantago lanceolata*, *Polygonum aviculare*-type and *Pteridium*, already present in the preceding zone in low numbers, have now increased.

Zone 4 (spectra 37-50) has been established where

the diverse group of deciduous tree types suddenly disappears. *Pinus* remains the dominant tree pollen type. The NAP values do not significantly change until spectrum 45. This is a reason to divide zone 4 into two subzones. In subzone 4b (spectra 44–50) *Pinus* pollen has decreased and NAP, represented by higher values for Chenopodiaceae, Liguliflorae, Tubuliflorae, Cyperaceae and Gramineae, differs from the preceding subzone 4a (spectra 37–43).

#### 7.11.8. Discussion

During the time that the lower part of the sediment was deposited in Kaz Gölü, an average of 10% tree pollen is found (zone 1). The dominant herb types are *Artemisia*, Chenopodiaceae, Liguliflorae, some types of Tubuliflorae, Cyperaceae and Gramineae, pointing to open, mainly steppic vegetation. The values of the various tree types found up to spectrum 12 are low enough to be the result of long-distance transport. Their source must be sought closer to the coast where in the same period tree pollen is found in large numbers. On the dry slopes steppe plants were found, whereas Cyperaceae profited from local wet conditions. Characteristic is the presence of *Carthamus* pollen and this large composite must have been common around the lake. This was the situation at any rate around 8700±80 (GrN-12791), which lasted to about 7000 BP, the last date obtained by interpolation.

The steppe vegetation around Kaz Gölü was the result of dry conditions, with a precipitation of less than 400 mm annually. About 7000 BP, conditions changed and pine forest spread over the mountains. The increase of pine pollen probably depressed the long-distance effect, because various types present in zone 1 are no longer found. On the other hand, some pollen grains of chestnut and beech are found, suggesting that these trees expanded in the forest along the Black Sea. Pine took over an area that was covered by steppe before, as is suggested by the disappearance of *Artemisia* and Chenopodiaceae. Liguliflorous pollen however still increase. Their values cannot be explained as an increase in Dandelion-type plants in the vegetation, since this insect-pollinated group never scores very high in modern pollen precipitation. Pollen of such plants must have been carried from open vegetations by updraught to precipitate subsequently in a cooler spot, above the water of Kaz Gölü (see also Bottema & Woldring, 1984(1986)). This situation continued throughout subzone 2a, ending about 5000 BP, as calculated by interpolation. If dating were done by pollen correlation, a younger date would be found for the beginning of subzone 2b. In this zone values for *Pinus* and Liguliflorae are lower and there is some increase of *Artemisia* and anthropogenic indicators as *Cerealia* and *Plantago lanceolata*. In other diagrams of Turkey (Bottema & Woldring, 1984(1986)) this pollen zone is dated about 4000 BP.

A conspicuous rise is also evident for *Alnus*, *Betula*, *Carpinus betulus* and *Corylus*. Such a phenomenon is very difficult to explain. *Corylus* could have been grown for its edible nuts, but the presence of other members of the Betulaceae family is more likely to be the result of a somewhat moister climate. It is very probable that such low pollen percentages do not indicate changes on the spot, as we have evidence that certain pollen types or even assemblages may precipitate outside the range where the pollen-producing vegetation was found. Still their behaviour indicates that changes took place somewhere.

The behaviour of some pollen types, especially in the first part of subzone 2b, is not easy to explain. The sediment changes from dark grey clay to blue-grey clay. Liguliflorae values drop from almost 50% to 20% and Cyperaceae and *Sparanium*-type increase. The combination of these two aspects would suggest moister conditions than those present in the preceding subzone 2a. Some increase of the various Betulaceae would be in line with such a climatic shift. However, contradicting such ideas is the decreasing arboreal-pollen percentage, caused by decreasing pine pollen, while at the same time *Artemisia herba-alba*-type, a steppic element, reaches c. 20%.

Zone 3 contains the typical pollen assemblage attributed to the Beyşehir Occupation phase (Bottema & Woldring, 1984(1986)), which is mentioned in this paper in section 8. Herb types, for instance *Polygonum aviculare*, *Plantago lanceolata*, and various Compositae as well as tree types such as *Alnus*, *Carpinus betulus*, *Ostrya*-type, *Castanea*, *Fagus*, *Quercus cerris*-type and *Picea*, increase.

The time covered by this phase lasted about 1700 uncalibrated <sup>14</sup>C years. In Kaz Gölü the beginning of the Beyşehir Occupation phase is dated 2220±90 BP (GrN-18624) which is later than in other records. On the assumption of a constant sedimentation rate, the end of zone 3 would be 1300 BP. In the majority of the Turkish pollen diagrams the beginning of this pollen assemblage is dated up to a millennium earlier.

Zone 4 represents the most recent fifteen hundred years, a period that is characterized by high pine-pollen values. Other tree pollen hardly if at all play a role. One could imagine that human pressure upon the environment became less during zone 4.

Herbs that are particularly well represented in zone 4 include Chenopodiaceae, Liguliflorae, Cyperaceae and Gramineae. The latter two types may have come from marsh vegetation, as they are present in Kaz Gölü nowadays.

From spectrum 45 on (subzone 4a) the pine forest disappeared, as is concluded from the decreasing pollen values. This event took place about 800 years ago (AD 1200) calculated on the basis of the radiocarbon date 2220±90 BP at 420 cm. The radiocarbon date 8770±80 BP, obtained for the level 950–960 cm, indicates that sedimentation was not constant but progressive,



possibly as an effect of compaction. In this case the final attack on the mountain pine forest around Kaz Gölü must have been considerably later than was the case for instance in nearby Lâdik Gölü.

## 7.12. Lâdik Gölü (figs 8 and 22)

### 7.12.1. Geography

Lâdik Gölü (40°55'N, 36°1'E) lies 7.5 km east of the town of Lâdik (fig. 8). The lake is found in the lower part of a valley at about 800 m, bordered to the south by the Karaömer Dağı. From this mountain ridge many small streams run northward to the lake. The Havza area west of Lâdik Gölü discharges into the northern part of the lake. During our fieldwork a man-made outlet was seen on the east side.

The lake itself lies in a flat area of wet meadows and marshes. The vegetation is grazed by cattle. Locally, extensive gravel fans occur, formed by the small streams coming from the Karaömer Dağı and discharging into the marshes. The lake is almost completely filled with a floating vegetation mat consisting of sedges, reeds, bulrushes, and some willow scrub. Between the floating vegetation and the lake-shore meadows is a strip of open water, as in the case of Kaz Gölü. This floating vegetation was inspected by means of a primitive boat and it was found that the floating island was in most places solid enough to carry cattle and herdsman.

The Lâdik area is influenced by the wintery winds which run parallel to the WNW to ESE orientation of the Canik Dağları (1100-1500 m). Hence, precipitation is relatively low (Erol, 1983). The marine influence penetrates quite far inland, because the mountains are not very high. South of the Canik mountains more continental conditions are found.

### 7.12.2. Climate

The average January and July temperatures for the Lâdik area measure c. 0°C and 20-25°C, respectively (Alex, 1983b). For Lâdik a precipitation of 800 mm is recorded (Alex, 1984).

The weather record of Amasya at 412 m gives 3.2°C for January and 23.9°C for July. An annual precipitation of 412 mm is measured, distributed over the seasons with 138 mm in the spring, 52 mm in summer, 76 mm in the autumn and 146 mm in winter. Amasya lies at a lower altitude and is 30 km further south in a more continental situation.

### 7.12.3. Present vegetation

Most of the area is cultivated, especially in the valleys. The valley that runs from Amasya to Lâdik is almost completely cultivated. Trees, such as poplar and fruit trees, were planted. Near Uzunoba, 17 km northwest of Amasya, a small mountain road through the western

part of the Karaömer Dağı was taken to Ahören, to study the forest remnants. The road towards Erboşa passes a barrage over Borrabay (900 m). Here most trees were seen between 600 and 900 m. The lower part, depending upon exposure and soil, is covered by *Carpinus betulus*. Most of the forest is regenerating from shoots after cutting and trees were about 20 years old. The landscape is maintained by local farmers with a grazing and cutting system.

At higher elevations a pine/oak forest with flowering *Crataegus* was encountered. On the higher parts of the eastern Karaömer mountains some snow (22th May 1984) and meadows could be seen with binoculars. At about 900 m *Quercus cerris* and *Quercus cf. infectoria* were found.

At the west side of the basin, 10 km north of Havza, some solitary oaks were seen in the almost completely cultivated basin. At some kilometres' distance deciduous forest was seen on the slopes. According to the map (fig. 5), the Lâdik area lies in a mixed forest of conifers and deciduous broad-leaved species resistant to cold.

Mayer & Aksoy (1986) give a scheme for the sub-Euxinian mountain area that includes Lâdik Gölü. At the lowest elevation in warm valleys, Mediterranean relics including *Pinus brutia*, *Juniperus* spec. and *Pistacia* occur. The hills are covered by *Quercus macranthera* and *Q. pubescens*. Submontaneous *Quercus petraea* grows in moister situations and *Pinus nigra* on drier soils. On sunny sides of the mountains a narrow belt of *Abies nordmanniana* is found, while fir occupies a broad belt on the shadow side. Drier soils carry *Pinus sylvestris*. The upper forest limit is formed by *Juniperus nana*.

### 7.12.4. The coring

The vegetation around the coring site was mainly formed by sedges and grasses. Flowering *Leucosium aestivum* was sometimes met with in large numbers. The sedge mat, the marshy meadows and the strip of water in between offered little opportunity for coring. Either the equipment could not be transported because of the inaccessibility of the marshy terrain, or no solid subsoil was present for coring. Closer to the foothills gravel and stones prevented sampling. In the southwestern part of the basin, c. 300 m from the Lâdik to Destek road, a soft clay was found. As walking and coring were almost impossible, planks were used to build a floating pathway and a platform to stand on during coring and in this way the sediment could be sampled.

### 7.12.5. Lithology

25- 81 cm	light-grey clay
81-100 cm	gyttja
100-130 cm	peat
130-150 cm	peaty clay
150-200 cm	soft grey clay with some peat or

	peat layers
200-325 cm	peat
325-375 cm	peaty clay
375-382 cm	peat
382-394 cm	clay
394-400 cm	sandy clay
400-475 cm	peaty clay
475-558 cm	grey-blue clay
558-625 cm	black amorphous peat
625-675 cm	brown peat
675-700 cm	black amorphous peat
700-725 cm	brown peat
725-739 cm	green-brown gyttja turning to brown
739-750 cm	blue clay with gravel
750-769 cm	no result, gravel falling out of sampler
769-851 cm	blue clay with gravel

Sampling was stopped because of a gravel layer which could not be passed through.

#### 7.12.6. Radiocarbon dates

GrN-18631	380-386 cm	2760± 50 BP
GrN-18632	408-411 cm	4280± 80 BP
GrN-18633	510-520 cm	6590± 90 BP
GrN-12790	716-719 cm	12,120±110 BP

#### 7.12.7. Pollen assemblage zones

Zone 1 (spectra 1-11) is characterized by low AP values and consequently high herb-pollen values, mainly *Artemisia*, *Chenopodiaceae* and *Liguliflorae*. This zone is divided into three subzones. Subzone 1a (spectra 1-5) is characterized high NAP values, mainly *Chenopodiaceae*, *Liguliflorae*, and *Artemisia herba-alba*-type. Tree pollen, mainly *Pinus*, is lower than 10%. Subzone 1b (spectra 6-8): AP values, mostly *Betula*, increase to about 50%. *Quercus cerris*-type gradually increases to 25%. *Liguliflorae* disappear, but *Artemisia* and *Chenopodiaceae* are still present. Subzone 1c (spectra 9-11): AP values are lower than in the previous subzone, except *Juniperus*. Between spectra 11 and 12 there is a hiatus in the pollen content.

Zone 2 (spectra 12-19): sudden high values of *Fagus* (46%), appearance of *Corylus* and *Carpinus betulus*. *Chenopodiaceae* and *Artemisia*-pollen values decrease. Appearance or increase of *Cereal*-type, *Polygonum aviculare*-type and *Pteridium*. In the upper spectra of this zone *Pinus* is on the increase. The herb types and the spores of *Pteridium* may indicate human activity.

Zone 3 (spectra 20-25): AP values reach maximum values in this zone, dominated by *Pinus*. Some anthropogenic indicators have disappeared. *Castanea* is present with a closed curve.

Zone 4 (spectra 26-40): deciduous broad-leaved tree species have reasonably high values, but *Pinus* has diminished to 20-30%. Tree pollen remains high, but fluctuations have led to the identification of subzones. In subzone 4a (spectra 26-31) the values for *Carpinus*

*betulus*, *Corylus* and *Fagus* are much higher than in the subsequent subzones. Many herb types, especially *Plantago lanceolata*, *Cereal*-type, *Sanguisorba minor*-type and *Pteridium* have relatively high values. Subzone 4b (spectra 32-36) is marked by lower values for deciduous tree species and the presence of *Platanus* and *Juglans*. *Cyperaceae*, *Galium*-type and *Equisetum* have important values. Subzone 4c (spectra 37-40) still shows the overall character of zone 4, but *Pinus* has already high values as were found in zone 3 and again in zone 5. *Juglans* peaks at the end of this subzone. *Cyperaceae*, *Galium*-type and *Equisetum* decrease.

Zone 5 (spectra 41-46): tree-pollen values are rather similar to those of zone 3.

Zone 6 (spectra 47-50): AP values drop from almost 90% to about 50%, owing to a strong decrease of *Pinus*; *Juglans*, *Olea* and *Pistacia* appear again. Various broad-leaved species, including *Carpinus betulus*, *Corylus*, *Fagus* and deciduous *Quercus*, are found together with a large variety of herbs.

#### 7.12.8. Discussion

The Lâdik record represents a period of about 13,800 uncalibrated radiocarbon years, interpolated from a  $^{14}\text{C}$  date of 12,120±110 BP at 716-719 cm. According to the distribution of the dates supplied by radiocarbon dating, sedimentation was irregular. The variety of the sediment also points to discontinuous deposition. The black amorphous peat deposited from 620 cm to 560 cm contained no pollen. This suggests that the basin dried out at that time, at least on and around the core location. Local hydrology and climatic conditions will have combined to cause the events. The result is that the period from about 10,000 up to about 7000 BP is not represented at all and the part from 7000 up to about 3200 BP is unreliable. It will be explained here why this conclusion was drawn.

The lowest part of the pollen diagram (zone 1a, spectra 1-5) is characterized by high herb pollen values of *Chenopodiaceae*, *Liguliflorae*, *Artemisia herba-alba*-type and some other *Tubuliflorae*. Most of these types are characteristic for this period, but the high values for *Liguliflorae* need more explanation. This taxon measures 30-50% in zone 1a, but such values are not found in modern vegetations, not even when *Liguliflorae* grow there abundantly. The high values in the lower part of the Lâdik diagram are considered to be anomalous. Still, the high number of *Liguliflorae* indicate dry and relatively hot summers.

Given the palynological evidence, an extreme steppe environment prevailed in the Lâdik area in zone 1a. Arboreal pollen percentages are so low that one might conclude that no trees grew in the vicinity and that any tree pollen present in the spectra was the result of long-distance transport.

In the next zone, 1b, some forest started to develop. Pollen of *Acer*, *Betula*, *Juniperus*, *Hippophae*, *Quercus*,

*Abies*, *Ulmus* and *Salix* is found. As the values are low, pollen may still have come from the coastal mountain ranges. Only the values for *Acer* point to the local presence of this genus. *Acer* has very poor pollen dispersal and is under-represented in the pollen rain. A few percent pollen of this taxon points to a fair number of *Acer* trees. Around 12,000 BP, birch probably formed the upper tree limit together with juniper, but the altitude of this limit is difficult to establish. The Karaömer Dağ, south of Lâdik Gölü, reach 1500 m. Birch disappeared from large parts of Turkey soon after the end of the Late Glacial (Bottema, 1990). It is very likely that this pioneer species formed the upper tree limit. The birch trees were pushed out of their zone (maximally 1500 m here) by the trees of the forest belt below, a shift initiated by climatic amelioration. As is suggested by high pollen percentages, a belt of deciduous oak was found below the birch zone. Because of the lower temperatures postulated for the Late Glacial, the lower limit for trees was found at a lower elevation than today. That it was not so much a forest limit as indeed a tree limit is suggested by the low AP values. While oak, elm and maple formed open stands, offering enough light for the growth of *Hippophae*, with birch at the upper level, *Salix* scrub grew along the shores of the lake.

Both periods, 1a and 1b, form part of the Late Glacial, but different conditions must have prevailed as is deduced from the pollen content and the lithology. From 820 to 750 cm blue clay with gravel was deposited, the upper part of which was so loose that it dropped out of the sampler. The gravel points to harsh climatic conditions, with occasional thunderstorms transporting coarse material from the foothills to the lake. Above 750 cm, the sediment turns into gyttja and peat, indicating a period with increased moisture, during which a vegetation cover developed that prevented erosion. In this way the sediment in Lâdik Gölü changed from gravelly clay to organic deposits. Pollen zone 1b seems to be contemporaneous with the Allerød oscillation as it is known from northwestern Europe.

The final part of this zone, 1c, starts with lower tree-pollen values than marked zone 1b. Pollen of *Chenopodiaceae* and *Artemisia herba-alba*-type are more numerous, from which an increase in steppe vegetation is deduced. Zone 1c has lower *Betula* and *Quercus* values than zone 1b. *Juniperus* and *Hippophae* are fairly important and some *Abies* pollen is encountered. *Hippophae*, a shrub under-represented in the pollen rain, was quite common and points to a very open landscape. Several types, such as *Carpinus betulus*, *Corylus* and *Fagus*, reappear with low values in the upper spectrum of zone 1, indicating that the conditions around Lâdik Gölü changed.

Zone 1c can be traced up to 630 cm, after which a black decomposed peat is found, devoid of any pollen. Because of a hiatus in pollen which lasted up to spectrum 12, no information about the transition of zone 1c to zone 2 could be obtained. The hiatus from c. 620 cm

to 560 cm covers a period during which changes took place that led to the new situation of zone 2. A group of deciduous tree species became dominant. *Betula* and *Quercus* decreased to low values. *Fagus* started with a share of 46% and *Carpinus betulus* and *Corylus* were important constituents. Conifers, including pine, were quite rare in the Lâdik area, but pine expanded towards the end of zone 2, from about 6600 BP onward.

In zone 2 deciduous forest must have been open enough for light-demanding herbs to play a role in the vegetation. On the other hand, part of the pollen types in the record point to early farming, since *Cerealia*-type, *Plantago lanceolata*-type, *Sanguisorba minor*-type and *Pteridium* are present. This evidence suggests that from about 7000 to 6000 BP the Lâdik area was farmed. This activity seems to have ended by the end of zone 2 (c. 7000 BP), when pine forest expanded. The period before zone 2, in which the peat layer between 620 and 560 cm was oxidized to black amorphous peat, coincides with the Boreal of Europe. It is possible that a dry and warm climate caused the desiccation of the organic deposit. Alternatively, one may postulate that precipitation increased at the beginning of zone 2, the new water supply creating an outlet which drained the basin. Because of the drainage the peat dried out and was oxidized, losing any pollen originally present.

The Lâdik area was dominated by deciduous forest for a short period around 6500 BP. The slopes were covered by hornbeam, lime, hazel and oak. At higher elevations extensive beech forest grew. Herb pollen values indicate that light could still penetrate the tree canopy. NAP values of 30-50% include *Caryophyllaceae*, *Chenopodiaceae*, *Artemisia herba-alba*-type, *Senecio*-type, and the anthropogenic indicators mentioned above. The development of farming in the Lâdik area would be contemporaneous with farming in the area of Lake Iznik, illustrated by the excavations of Ilıpınar. Pollen indicative of farming does not appear before around 4000 BP and its early appearance in zone 2 is rather unusual. At this time the sediment consists of organic clay and one wonders if it was formed under a floating sedge mat. This could have taken place after a period of desiccation of the peat layer, from 720-560 cm. The upper 60 cm were already oxidized, judging the absence of pollen grains. After the desiccation, peat was formed again and when the water level rose again, a large mat started to float, as can be seen nowadays. The water underneath the peat was gradually filled in with clay and younger pollen. Thus the sequence that was formed on top of the growing peat, was copied under this floating mat. Such a pattern of sediment repetition is known from several sites.

Judging from the pollen diagram it was material from spectra 26-47 which contributed to the formation of the floating sedge mat, that also arrived in the underlying clay deposit. It is true that the doubling does not include all types in the same percentages and that the radiocarbon dates display a normal succession. The

datable material, organic debris, consists of peat fragments from above that sedimented in the heavy, mineral fraction, thus supplying the forelying dates at 520, 410 and 380 cm.

Zones 2 and 3 thus are very difficult to interpret as a normal stratigraphy and therefore will not be discussed here botanically.

From spectra 25–26, the beginning of zone 4 onward, peat was deposited and the pollen of this deposit will be used to reconstruct the vegetation of the Lâdik area. In zone 4a a diverse vegetation covered the slopes of hills and mountains around the lake. Oriental hornbeam, common hornbeam, beech, oak and sweet chestnut occurred in the vicinity. At higher elevations, on the mountains at some distance beech, and more sparse pine forest was found. According to their respective pollen values it is deduced that beech pre-dominated over pine. Juniper grew in dry sunny spots, and around the lake and along brooks, willow and alder were encountered. The period when this vegetation was found is not exactly known. The pollen of sweet chestnut, walnut, olive, cereals, plantain, knotgrass (*Polygonum aviculare*) and spores of bracken (*Pteridium*) are indicative for the Beyşehir Occupation phase, known to have begun at 3200 BP. The organic material dated in the clay deposit at  $2760 \pm 50$  BP probably arrived from somewhere above, or leaked through the sedge mat. The level of the peat layer above spectrum 27 is not dated by  $^{14}\text{C}$  and is tentatively dated by cross correlation with other, dated diagrams. That would date the beginning of zone 4 to about 3200 BP, assuming that the complete period is represented.

After spectrum 31 (in zone 4b) the pollen picture changed rapidly. Values of hornbeam, hazel and beech suddenly decreased and only oak maintained its level. The attack on the medium and higher-altitude forest seems to have been rather sudden, but calculating from the sedimentation rate and realizing that the sample distance from spectrum 31 to spectrum 32 is 20 cm, we find that it still took about 160 years. Increasing pressure exerted upon the environment of Lâdik thus may have lasted about five generations. The change in the vegetation dominating the landscape between the time of zone 4a and that of zone 4b points to increased activity of farmers. To explain this activity is not simple. Did the population increase, causing a loss of natural elements? Was there a change in farming economy only? Intensive cultivation, crop growing, does not seem to affect the overall vegetation visibly in terms of pollen. Extensive herding, however, involving a few herdsman only but with a large number of animals on the move, exerts far more pressure upon the vegetation of a vast area. The next question that arises is: did herding develop and why? There may be several reasons to own large herds. In fully nomadic systems, status may play a role. In the transhumance of southern Europe and southwestern Asia, economic motives seem to prevail (Reinders, 1994).

The beginning of zone 4b can be dated from the assumed sedimentation rate of 8.6 year/cm. One has to keep in mind that such a calculation assumes a constant sedimentation rate and an initial date of 3200 BP for the start of zone 4. If this is correct, zone 4b started about 2580 BP. Such a date has to be compared with other, historical evidence from the coastal area of northern Turkey in that period.

The pollen values characteristic for zone 4b, are maintained up to spectrum 36, at about 2000 BP. The occupation and exploitation of the Lâdik area then faced new changes, deduced from the lowering of oak pollen values. This reflects further deforestation of the slopes. The AP curve in the main diagram (fig. 22) still shows important values of 70–85%, mainly due to *Pinus*. Pine may have increased in numbers as a secondary forest in those parts where forest had been cleared before. The increase of pine pollen can also be explained as being relative, a consequence of the disappearance of other tree pollen types.

From the pollen evidence of zone 4c it can be seen that fluctuations in pollen content happened and this might have been caused by a varying intensity of occupation. Still the overall trend in this zone is a progressive loss of natural vegetation. The end of zone 4c (spectrum 40) is dated at about 1500 BP. This is roughly the time of important demographic shifts in Europe and Asia Minor, but it still has to be proved that there is a relation between the two events.

Zone 5 reflects a period of at least partial regeneration of vegetation, which may resemble such a phase occurring in Europe at about 400 AD (Frenzel, 1992). It is not self-evident that the turbulent history of the Byzantine empire is recorded in the vegetation pattern. Even when historical events strongly influenced the economy, it is not certain that this affected the pollen precipitation significantly. Demographic changes in Greece during the last millennium could not be seen in the pollen record (Bottema & Woldring, 1990). In zone 5 of the Lâdik diagram it seems that wasteland developed, giving rise to secondary pine forest. This is also supported by a large-scale decrease of anthropogenic pollen indicators, illustrating considerably reduced human pressure upon the environment. The fact that pollen of deciduous forest of medium levels did not increase at all, suggests that extensive herding was still practised although sedentary agriculture had disappeared. Calculated from the same sedimentation rate mentioned above, zone 5 lasted until about 600 BP, roughly the end of the medieval period.

The upper part of the Lâdik diagram, about 70 cm, represented by zone 6, shows the return of deciduous tree pollen types, originating mostly from the level of Lâdik Gölü; only the beech forest may have occurred at higher levels. The total proportion of tree pollen is now lower, because of a considerable decrease in pine percentages. The indicators of farming increase, including those types that indicate local activity and those that can

only have been cultivated in a typically Mediterranean environment, such as olive. This phase must be very young because *Zea mays* pollen is found. That dates spectrum 48 later than its calculated age of some 600 years. Maize is an American introduction and came into use as a cultivar centuries after it was first brought to Europe. Pollen of *Cornus mas*, *Sambucus nigra*, and *Viburnum* indicate that the forest at higher elevations had largely disappeared and that scrub spread.

In contrast with the preceding zone, zone 6 has pollen values pointing at crop cultivation dominating over cattle rearing or at least extensive herding. The land at some distance from the settlements was left unexploited. A situation that resembles that in zone 5 was seen in 1993 in southern Albania between Kakavia, Butrint and Konispol, where extensive herding took place on abandoned arable land. This change in exploitation was the result of an important change in the political system (Bottema & Reinders, 1994).

### 7.13. Tatlı Gölü (figs 8, 23 and 24)

#### 7.13.1. Geography

Tatlı Gölü (41°35'N, 36°4'E) lies in the flat coastal area, northwest of the town of Samsun (fig. 8). It is a small lake in the Bafra Ovası (= district), 12.5 km east of the town of Bafra and a few hundred metres west of the large Balık Gölü (fig. 23). The low marshy Bafra area is characterized by muddy alluvial clays, silts and sand with smaller and large lakes. The large headland was formed by the river Kızılırmak which deposited a large amount of material, thus shaping its delta. Sand bars and ridges were formed by sand brought along by the river together with the waves and coastal currents of the Black Sea. A large sand bar was deposited from the northwest to the southeast. Behind this sand bar a series of lakes were formed, starting in the northwest with Liman Gölü, followed to the east by Cernak Gölü, Balık Gölü (Ulu Gölü), Gici Gölü, and connected with this lake, Tatlı Gölü in the south.

The landscape in the Bafra area is slightly undulating, partly originating from pre-Holocene times. The lake of Tatlı is separated from the much larger Balık Gölü by low ridges which may have originated as sand bars. In front of one of these ridges water stagnated, creating Tatlı Gölü, and a sediment was deposited. At present, the river Kızılırmak is 15 km away. From the sediment it is concluded that the river never discharged into the lake, as no sand and/or gravel were encountered. Small streams of local origin also contribute to the system, by running from the foothills towards the Black Sea. Some of them even start in the delta itself.

East of Samsun, the Yeşilırmak river has transported a large amount of sediment far into the Black Sea. The flat area, with Çarşamba in the centre resembles the Kızılırmak delta. In the northeast, in front of the sand ridge, sediments were and still are being deposited. Two

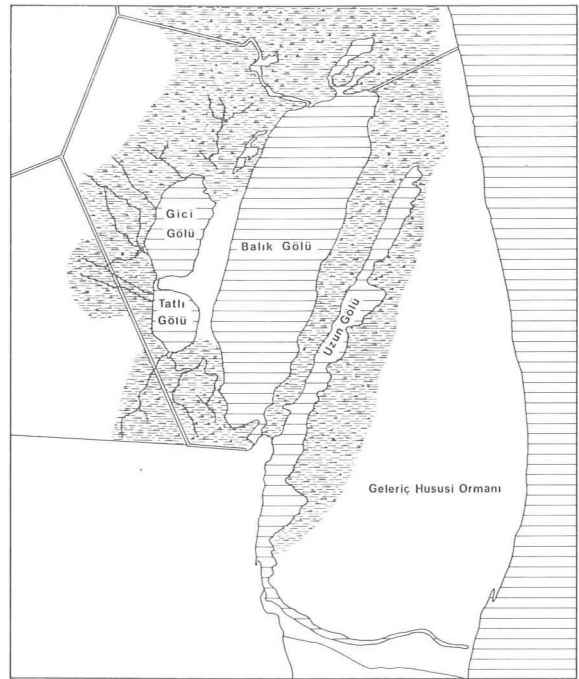


Fig. 23. Delta of the Kızılırmak river with the location of Tatlı Gölü and coring site.

large lakes are found here: Simenlik Gölü and Akgöl. Locally, drainage canals and ditches have been dug to make the clay suitable for agriculture. However, the drainage has mostly produced grazing grounds for cattle. Large areas are covered with spiny tussocks of *Juncus cf. acutus*.

#### 7.13.2. Climate

For information about the climate of the Tatlı Ovası and the Çarşamba Ovası, the clima-diagram of Samsun (44 m) (Mayer & Aksoy, 1986) is used. The average January temperature is 6.9°C and for July a temperature of 23.0°C is recorded. Average annual precipitation is 735 mm. According to TAVO map A IV 4 (Alex, 1984) precipitation for the Çarşamba Ovası is more than 800 mm.

#### 7.13.3. Present vegetation

The core was taken at the edge of Tatlı Gölü where a grazed marsh vegetation was flooded. The flooded area showed signs of seasonal shrinking (24th May 1984). A nearby stubble field was already dry, but flowering specimens of *Alisma plantago-aquatica* stood in the furrows. For some reason the field was in a state of neglect. Although surrounded by low dikes, it had been flooded. Near the coring location a plantation of pollarded *Fraxinus excelsior* stood in water c. 50 cm deep. Farmers said that the pollarding was done to grow

wood for fuel, and out of reach of browsing cattle. Under the ash-trees grew tall grass of *Glyceria*-type and orchids. Quite probably the water would retreat during the dry season.

*Fraxinus excelsior*, *Alnus glutinosa* and *Populus* (poplar and ash mainly planted) were found during the fieldwork in the Çarşamba Ovası. In the deltas of both the Kızılırmak and the Yeşilirmak, especially on compacted soils near houses and along roads in villages, such trees were very common. Occasionally abundant *Leucojum aestivum* was observed. At the edge of the headlands, very probably influenced by the salt water of the Black Sea, extensive fields of *Juncus* cf. *acutus* were found, which grew on wet, solid clay. More inland, stagnant water was found on clay that did not carry much vegetation. Higher sandy parts were planted with pine species by the State Forestry Service.

#### 7.13.4. The coring

Several attempts were made to sample the two river deltas, but without much result. Hard, impenetrable yellow clays, sand or gravel were present. A motor boat was used to visit small islands in Simenlik Gölü. One of these islands produced a short core of 46 cm of clay, gyttja and peat, the others were even less successful because sand or gravel was hit immediately. Coring in the shallower parts of Simenlik Gölü as well as along the water in the clay did not yield any pollen material. On May 25, 1984, the edge of Tatlı Gölü, where grazed marsh vegetation had been flooded, was tried to sample and this location turned out to be successful (fig. 26).

#### 7.13.5. Lithology

0- 10 cm	water
10- 85 cm	grey clay with yellow spots
85-150 cm	sticky yellow clay, sometime with black spots, difficult to penetrate
150-225 cm	grey to dark grey clay
225-345 cm	light-grey to grey-blue clay, the bottom 15 cm with <i>Cardium</i> shell fragments, easy to penetrate
345-560 cm	soft light-grey clay, sometimes sandy
560-760 cm	grey-green clay, sometimes with organic remains. <i>Cardium</i> fragments at 670 cm and 710 cm
760-814 cm	amorphous peat, clayey in parts
814-907 cm	grey clay, sometimes with organic remains

At 907 cm sand was found that could not be sampled and coring had to be stopped.

#### 7.13.6. Radiocarbon dates

GrN-12789	798-806 cm	5945±45 BP
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#### 7.13.7. Pollen assemblage zones

Zone 1 (spectra 1-6): AP values are about 80%, mostly *Pinus*.

Zone 2 (spectra 7-13) is identified (despite hiatuses in pollen) on the basis of lower *Pinus* percentages, whereas *Alnus*, *Carpinus betulus*, *Corylus* and *Fagus* show the highest values of the whole sequence.

In zone 3 (spectra 14-21) *Pinus* values increase from about 5% to about 40%. Values of pollen from deciduous species are low, except for *Quercus*.

Zone 4 (spectra 22-24): *Pinus* pollen increases to c. 70%. Other tree types have almost disappeared.

#### 7.13.8. Discussion

It was not possible to prepare a complete diagram from the Tatlı core because of the absence of pollen in many parts. Where the sample distance exceeds 50 cm in the Tatlı diagram, hiatuses in pollen were identified. The lack of pollen could be attributed to oxidation of the sediment in the upper part of the core, where the lithology indicates yellow clay. In the deeper part such indicators are not found and the absence of pollen in those parts may be due to very rapid deposition, caused either by floods from discharging streams or by marine action. A time estimate based on interpolation from the only radiocarbon date at about 800 cm should be considered with the utmost caution, as such calculations assume a constant sedimentation rate.

During the earliest period, zone 1, arboreal pollen measures c. 80%. The spectra are dominated by *Pinus* pollen but it is not likely that pines grew in the delta. At present *Pinus* grows or potentially is found in large parts of the Pontic region. Near Sinop, *Pinus nigra* is found from coastal levels up to the summits of the coastal range. The pine pollen in the Tatlı core will have been blown in by winds coming from the mountains or they were carried in by streams coming from that direction.

The vegetation that covered the higher parts of the delta and the adjacent foothills was formed by deciduous forest which included *Carpinus betulus*, *Quercus*, *Fraxinus excelsior* and especially *Ulmus*. *Ulmus* was abundant in zone 1. Interpolation produces a date of about 5500 BP for the level of 740 cm, the end of zone 1.

Zone 2 lasts from about 5500 to 2400 BP, a period interpolated from the radiocarbon date of 5945±75 BP at a depth of 800 cm. This part is marked by lower AP values for all major types. From spectrum 8 onwards deciduous tree types increase again. This group maintains important values up to spectrum 13. In zone 2, pine values are relatively low.

It is difficult to interpret these spectra. It is quite certain that the deciduous trees grew in the lowland of the delta. The sediment contains fragments of cockle shells which must originate from the Black Sea. Either

the water of Tatlı Gölü formed part of the Black Sea at that time or water from the sea was blown in or washed over sandbars that separated the lake from the sea. The low values of *Pinus* pollen may point to a (local) change in water transport. *Pinus*-pollen bearing streams coming from the mountains no longer discharging into Tatlı.

Zone 3 is separated from zone 4 by a few spectra with low pollen values for deciduous types. In this section, spectra 14-16, pine-pollen percentages increase. The middle of zone 3 saw an increase in *Quercus* together with a maximum of *Pinus* pollen. Both tree types decrease towards spectrum 21, where a maximum of *Liguliflorae* is found. The high values of these composites point to oxidation of the sediment as can be read from the lithology (7.7.5).

Finally, in zone 4 a dominance of pine pollen may be related to a common occurrence of this tree in the mountains south of the delta. The younger spectra in Turkey generally demonstrate such high *Pinus* values, which may be a result of the disappearance, due to human exploitation, of all the other types.

The Tatlı record mainly illustrates the contrast of a group of deciduous tree-pollen producers on the one hand and pine and herbs on the other. In this respect the information from the lithology is also of interest. The local deciduous forest was influenced by the hydrological conditions, for instance salt water from the Black Sea at the beginning and the end of zone 2. During the time of zone 3, human activity must have reduced local deciduous forest. A primary anthropogenic indicator, Cerealia-type, will be difficult to ascribe to crop-raising, since many wild grasses have the same pollen type (Bottema, 1992a,b). Secondary indicators, e.g. *Plantago lanceolata*, indicate farming activity in the area from about 2400 BP onward.

#### 7.14. The relic stands of cedar near Erbaa

*Cedrus libani* is found in two small stands between Akinci (Niksar) and Çatalan (Erbaa) in the area of the river Kelkit (fig. 8) together with *Carpinus betulus*, *Quercus cerris*, *Pinus nigra* and *Pinus sylvestris* (Atalay, 1987). The main distribution of *Cedrus* in Turkey is Oro-Mediterranean and its former distribution is discussed in van Zeist et al. (1975) and Bottema & Woldring (1984(1986)).

One would expect the pollen precipitation to be best reflected in surface samples collected in the neighbourhood of the Kelkit valley (Nos 8-19 in fig. 7). It turns out that *Cedrus* pollen is hardly represented in these samples. Only in samples 9 and 10 does one cedar-pollen grain appear. Studies into the prevalence of *Cedrus* pollen in the southwestern part of Turkey (van Zeist et al., 1975) demonstrate that this pollen is very much under-represented in samples that have not been collected from cedar/juniper forest. Sediments from lakes and swamps in the Pisidian district, where cedar forms an important part of the vegetation, show fairly

high values. For the Holocene period these values fluctuate between 10 and 70%. The diagram of Akgöl, in the steppic plain east of Konya, still displays up to 5% *Cedrus* pollen. It is unlikely that the species grew in the plain in early times, and its pollen must have been carried to the marshes from further away. Thus in an area with optimal growth of *Cedrus*, the fossil pollen record seems to be a suitable source of information.

In the northern part of Turkey where the two small stands of *Cedrus* are found, the pollen diagram of Lâdik is the nearest source of information on fossil pollen from earlier stands of *Cedrus libani*. *Cedrus* pollen is found in various samples throughout the record, with low values of at most 1%. Neither the surface-sample study nor the fossil record indicate that cedar was more common in earlier times. In this respect the information from other pollen cores is instructive. Cores that were taken farther away from Lâdik Gölü and Erbaa, e.g. Kaz Gölü and Abant Gölü, show *Cedrus* values which are sometimes even higher. The same is true for a core from the Uludağ region near Yenişehir that also has an discontinuous series of low *Cedrus* values. The low values in Lâdik cannot exclude that cedar was planted by man in that area in subrecent times, but there is also no proof of such artificial distribution. However, it is clear from the pollen record that in the past cedar was not found in larger numbers than nowadays in the Erbaa region.

## 8. THE INFLUENCE OF PREHISTORIC MAN UPON THE VEGETATION OF NORTHERN TURKEY: CULTIVATION, GRAZING AND TRANSHUMANCE

Earlier studies on the Late Quaternary vegetation development of southwestern Turkey (van Zeist et al., 1975; Bottema & Woldring, 1984(1986)) and eastern Turkey (van Zeist et al., 1968; van Zeist & Woldring, 1978) informed us about changes in the pollen record that could have been the result of the activity of prehistoric people. Such evidence was also looked for in the present study.

In general it can be stated that the presence of settled people is no guarantee that changes in the pollen rain can be observed, linked with some kind of human activity. This was concluded from pollen diagrams that originate from areas where there is proof of Early Neolithic habitation. In such diagrams, changes that can be ascribed to human activity occur much later, around 4000 BP.

One may wonder whether it was the scale of the activities that was decisive for the effect upon the pollen production of the surrounding vegetation. It is certain that the nature of the activities is reflected by changes in the pollen picture or the absence of an expected change. The kind of vegetation present at the time of human occupation plays a role in the actual change in the pollen

record. Lumbering, whether for house or ship building, to obtain fuel for stoves or metallurgy or to obtain farmland, will not result in a depression of the number of tree pollen as long as a certain amount of trees remain. The opening up of a closed canopy will initially even cause a higher pollen production. In a closed canopy the number of flowers per tree is lower than in stands of trees that receive more light when they form side branches around a clearing. The number of tree pollen will gradually decrease as more and more trees are cut. At the same time when the forest is cut, ground cover increases and more pollen of herbs can be expected. The herb-pollen values do not rise proportionally with the increase in open space. Modern pollen precipitation, for instance in the Greek Pieria mountains (Bottema, in press a) shows a higher arboreal/non-arboreal pollen ratio in samples from scrub than in samples from forests. Tree pollen is thus even better represented in scrub vegetations than in the forest, mainly because few herbs grow under shrubs, flowering can be profuse and pollen from the forest from higher levels is transported downward. Forest clearance can only be traced by a significant lowering of tree-pollen values in relation to herb-pollen values.

Farming itself has other effects on the composition of pollen assemblages. To make the effect visible, the distance of the pollen site to the prehistoric settlement should be short, preferably less than one kilometre, a fact seldom realized. Traditionally, farming has included animal husbandry and crop cultivation, but this has not been the case everywhere, all over the world. Certain American Indian tribes developed advanced cultivation without animal domestication and protein was obtained from beans or by hunting or fishing. Pollen diagrams from such areas do not demonstrate human impact before the arrival of European colonists, although farming was practised. The fact that this farming cannot be inferred from the pollen record must be linked with the economic pattern; these Indians had no animal husbandry!

One might expect farming to be represented by the pollen of the crops whose presence is proved by many excavations. Van Zeist demonstrated the cultivation of a variety of crops in the Near East, beginning with aceramic settlements in the Fertile Crescent where an extensive assortment was present from the start. Cereals include *Triticum monococcum*, *T. dicoccum*, *T. aestivum*/ *durum*, *Hordeum vulgare* (various subspecies). Apart from the cultivars, wild ancestors of wheat and barley occur in the Near East together with *Secale* and *Aegilops* species and other wild grasses which all have pollen grains that can be identified to a certain level in theory but that in practice are generally lumped as Cerealia-type. Experiments with the pollen production and dispersal of cereal domesticates show that wheat and barley are very much under-represented in the pollen precipitation (Bottema, 1992a,b). The self-pollinating species or their derivatives produce reasonable amounts

of pollen which, unfortunately, do not end up in the pollen precipitation. The pollen mostly remains in the bracts, or drops directly to the ground under the plants. A small percentage of einkorn wheat is cross-pollinating and may be found in the subfossil record from time to time. The group of cereals is separated from the majority of the grasses by the size of the pollen grain and the shape and size of the annulus, but these features do not enable us to separate them from *Aegilops* and some other grasses. Cerealia-type includes pollen of cereals but the latter cannot directly be proved (van Zeist et al., 1975).

Other crops grown by early farmers are lentil, bitter vetch, chick pea and flax. They are all poor pollen producers and the majority cannot be identified to the specific level if found at all. Pollen analysis does not seem to be a very appropriate method for demonstrating crop cultivation.

The diagrams treated in this study have to be screened for other indicators more suitable for proving the presence of human habitation. The evidence relating to other parts of Turkey which has appeared so far is very helpful in this respect. If the pollen of crops is not very suitable for detecting cultivation, indicators have to be looked for that display the effect of animal husbandry. Grazing, the exploitation of biomass that is within reach of the animals, required human intervention in many parts of northern Turkey where the vegetation was a heavy forest with limited vegetation on the forest floor. The high canopy cannot sustain livestock.

If a vegetation is being prepared or already fit for grazing, it differs appreciably from the preceding dense forest. Persistent grazing will turn it into a vegetation that is artificially maintained or that is gradually degraded, sometimes even leading to a vegetationless, barren and eroded landscape. Such situations are characterized by plant species some of which can be traced in the pollen rain (Bottema & Woldring, 1990). This is based upon studies of modern vegetations and their representation in the pollen rain.

In the Holocene diagrams of Turkey several herb pollen types first appear or increase somewhat around 4000 BP, for instance *Plantago lanceolata* and other plantain species, *Polygonum aviculare*-type, *Sanguisorba minor*/ *Poterium*, *Artemisia* and *Rumex*. Besides pollen, spores of *Pteridium* are found. This pollen and the *Pteridium* spores are produced by plants that benefit from grazing. Their presence does not necessarily have the same cause but they share one prominent requirement: the presence of light in the vegetation. They are not so much stimulated by grazing of the herb cover itself – they may even be eaten by cattle, sheep or goats – but they benefit especially from the destruction of the primary forest and the successive browsing and grazing of the regenerating young trees. Rejuvenation and regeneration of trees or forest is prevented by the continuous pressure of the farm animals. Grazing will have taken place in those parts of the forest where trees had been felled for house-building and other purposes,



for instance ore melting for which large quantities of wood were needed. If such activities took place and no grazing followed, the forest would regenerate and light-requiring herbs would disappear.

The nature of grazed land and the total surface that it covered in the landscape changed through time and was directly related to the economy, the number of people and the level of technology. The grazing impact became especially important when the number of livestock rose in connection with urbanisation. Locally, the number of animals was limited by the available space. Any increase would have created shortage of fodder or serious conflicts with crop farming. That such conflicts may have arisen early in the development of the Neolithic is suggested by Köhler-Rollefson (1990) for Jordan.

At a time when a considerable part of the human population demanded meat, milk products, wool or hides that they themselves did not produce, the economic importance of larger herds rose. For these herds grazing grounds were needed and it depended upon the local situation whether they were present at all and during some or all seasons. In the typical Mediterranean, at lower levels along the western and southern coast of Turkey, grazing is available mainly during the winter half-year, as a result of the climatic regime. In such environments sheep or cattle had to be herded to places where food was available during the summer. If nearby mountains were high enough to have meadows above the timber line these could be exploited. Forest was attacked not only from the lower levels, but also from these mountain meadows. Fire and lumbering depressed the timber line artificially and finally all the forest might be cleared. The higher parts of many mountain ranges in Turkey have a harsh winter climate with snow cover. It is clear that they do not offer any winter grazing, but summer conditions are much cooler because of the elevation, and biomass production alternates with the low-level Mediterranean where stubble and fallow and scrubland is used. Such a grazing system could only exist if certain conditions were fulfilled. There had to be summer and winter ranges in the area, and in cases where they were found far apart, the political system had to guarantee free access. Before the development of great empires, territorial claims and rights could prevent any livestock driving over larger distances. The economic demand as well as the political situation were decisive and responsible for the rather late development of this system that we know as 'transhumance'. The seasonal travel of large herds, e.g. several thousand sheep, or smaller numbers of cattle or camels, sometimes over hundreds of kilometres in the Balkans, Turkey, up to Afghanistan, could only have been possible from the beginning of large empires. In this respect it is interesting that Aronson (1991) shows that the keeping of reindeer herds in Scandinavian Lapland developed in the 17th century only when the demand for meat in towns grew.

The change of forest into grazing grounds and the impact of grazing during the growing season resulted in

the appearance of certain indicators in the pollen rain. Apart from a depression of arboreal-pollen values which on the whole remained high, the appearance is noted of members of the group of pollen types listed above (*Plantago lanceolata* etc.), around 4000 BP. The system shows different types in the lower Mediterranean area than in the northern region, which has another version of the Mediterranean climate and lies at a much higher elevation. For the Bolu area, at 1300 m, grazing must have taken place in the summer half-year mostly, since to the information of local State Forestry people, the winter sees heavy snow cover. For the Yeniçağa area at about 970 m, winter conditions are less harsh. This area may have been exploited for a longer period and the extensive marsh area offers excellent cattle grazing. One has to keep in mind, however, that the quality of fodder, for instance the protein content, is high during the growing season and much lower at other times.

Some parts of northern Turkey cannot have been included in a periodical grazing system because they are forested even today and very inaccessible. The forested area has no alpine or subalpine meadows by nature and at present beech and fir forest grows up to the summits. Grazing of some uplands could only be effected by entering them from inner Anatolia, from the steppe region where there was open space above the timber line due to the climatic regime. The forest will have been attacked from this side and through the valleys.

From the foregoing it is clear that vegetation can be exploited economically only in the growing season when there is green biomass that includes palatable species. Animals do not survive upon such conditions only but they have to eat all the year round and provisions have to be made. It was already indicated in the example of the Yeniçağa basin that vegetation systems are quite independent from the Mediterranean climate in basins where water accumulates. In such basins lakes, swamps, marshes or wet plains may be formed inhabited by water and marsh plants, offering grazing grounds especially for cattle or water buffalo. Such vegetation may change under a grazing regime but it is not clear whether the change is fundamental and can be read from the pollen diagram.

It seems likely that the production of certain characteristic pollen types is caused by the grazing of flocks of sheep and goats on the mountain slopes. To maintain suitable grazing grounds, scrub vegetation that may develop has to be burned down by the shepherds. Developing *Quercus coccifera*/Phillyrea may be influenced by goats and less by sheep but it cannot be controlled completely by the animals. The floor under *Quercus coccifera* trees or dense scrub carries almost no vegetation and is covered by the dead, dry prickly leaves of the oak. If such vegetation is burned down, new green sprouts will appear from a variety of herbs and regenerating shrubby oak. Part of this vegetation forms good food for goats and sheep, while the impalatable plants also thrive, for instance *Origanum*,

*Thymus*, *Majoranum*, *Phlomis* and *Osyris*. In northern Turkey such vegetations do not play a role, and the change of the Hyrcanian forest into open grazing is different from the developments in Eu-Mediterranean parts. In the present study we are dealing with three main categories (fig. 5):

- The steppic part, represented by the diagrams from Tuzla and Seyfe Gölü;
- The mountainous part, represented by the diagrams of Abant, Yeniçağa, Lâdik, Kaz and Demiryurt Gölü;
- The coastal part, with diagrams from the Sakarya area and Tatlı Gölü.

To connect palynological changes in the diagrams from northern Turkey with grazing is not easy. The problem is that there are changes, but it is hard to prove that such changes are directly related to the northern mountain area and that they are not produced by events in the western and southwestern part of Turkey. The reason to doubt the origin of some indicative pollen types found in the northern Turkish mountain area is for instance the presence of *Olea*. The olive cannot have occurred in the uplands of northern Turkey and even in the lower parts it is rare nowadays. The pollen percentages of *Olea* during certain periods are remarkably high for sites at such high elevations. The top parts of the pollen records as well as the modern surface samples have values that are much lower than the percentages in the subfossil spectra appearing in the 4th millennium BP. Still the high values must have been caused by long-distance transport from southern or western Eu-Mediterranean regions to the north or from stands along the Black Sea coast. The latter possibility seems unrealistic because contemporaneous samples from the north coast have very low *Olea* percentages. At low elevations, Melen Gölü (fig. 11) shows values of 0.5% *Olea* at most. Pollen of the olive tree is hardly represented in the record of Tatlı Gölü in the lagoonal delta of the Kızılırmak, suggesting that the tree was not grown there in prehistoric times. The question remains whether this pollen originates from western Turkey where a large part of the countryside is marked by low elevations or from the south coast where a narrow strip of olive groves borders the sea. At low elevations only some river valleys, penetrating into the interior, have olive trees. The values in Abant, Yeniçağa, Kaz and Lâdik Gölü suggest a gradient that indicates transport from south to north. If olive pollen was transported over long distances, maybe hundreds of kilometres, the question is whether the types that indicate grazing were not blown in from other areas also.

The changes pointing to human impact, observed in the pollen record at about 4000 BP, are followed by a more pronounced palynological development around 3200 BP. This characteristic change has already been described for southwestern Turkey (van Zeist et al., 1975; Bottema & Woldring, 1984(1986); 1990) as the Beyşehir Occupation phase. Apart from the anthropogenic indicators described above, pollen of *Juglans*

*regia*, *Castanea sativa*, *Fraxinus ornus* and *Platanus orientalis* characterize this phase. The conspicuous pollen assemblage appeared directly after the Santorini volcanic eruption in c. 1629 BC (Bottema & Woldring, 1990). The period of the Beyşehir Occupation phase is present in the records of northern Turkey apart from those of Küçük Akgöl, Adatepe, Büyük Gölü, Demiryurt Gölü and Tuzla Gölü.

The manifestation of the Beyşehir Occupation phase is not equally strong in all diagrams. The lowland sites of Melen Gölü and Tatlı Gölü show it only weakly compared with the pollen record of sites on the Anatolian plateau. The radiocarbon dating of the phase is not always the same and the typical indicators are used to correlate the respective pollen diagrams. The mobility of *Olea* pollen especially enables correlation over large distances.

It is worthwhile in this respect to consider what we know about human habitation in various parts of Turkey around 3200 BP (calibrated c. 1500 BC). At that time Hattusa, 160 km east of Ankara and 25 km north of Yozgat, was the capital of the Hittite empire. Part of the Hittite empire, including the capital Hattusa, lay in the area covered by this palynological study. The evidence from Tuzla and Seyfe Gölü that might inform us about the influence of the Hittites upon their surroundings is unfortunately of restricted value. The sites of Kaz, Lâdik and Tatlı Gölü, which are more informative, were situated in the area that seems to have been inhabited by the Kaska, people living in the mountains north of the Hittites. These tribes did not leave written documents with information on agriculture as the Hittites did. For both areas no connection between written information and palaeobotanical evidence can be made because in both cases one of the sources fails to supply evidence. The influence of the Hittite empire also covered the Pisidian Lake district. The vegetation history of those parts was studied by van Zeist et al. (1975) and Bottema & Woldring (1984(1986)), and includes the Beyşehir Occupation phase. The Hittites may not have had comparable agricultural developments in the central part of their domain but they certainly were informed on the developments that took place in the southwest of Turkey.

About 1200 BC the Hittite empire collapsed. There are different opinions on the cause of the fall. Some authors consider a change to climatic dryness responsible for food shortage and famine and finally resulting in the destruction of the empire. Neumann & Parpola (1987) have a similar explanation for the decline of the Assyrian/Babylonian empire at about the same time. Documents in cuneiform script describe failing harvests caused by drought, and subsequent famine. Proxy data supporting these events (Kay & Johnson, 1981) are invalidated by other evidence (Bottema, 1993). Some authors (Bittel, 1983; Otten, 1983; Klengel, 1974) point to political and military causes, leading to a decline of various powers. Drought is often used by archaeologists to explain the

fall of empires or the disappearance of cultures. Famine is indeed not a sound basis for the continuation of a society. Yet it is quite a common phenomenon in history and advanced and large communities especially are hit hard by the hazards of a deviating weather pattern. Famine, felt throughout the country, occurred in France twenty-six times in the 11th century and sixteen times in the 17th century (Ponting, 1991).

For northern Turkey as well as for the adjoining southwestern part of Anatolia ample evidence on the vegetation history is available for the two millennia BC. As stated in earlier publications (van Zeist et al., 1975; Bottema & Woldring, 1984(1986)), moisture conditions improved from about 1600 BC up to about AD 400. The rapid spread of the Beyşehir Occupation phase and the expansion of forest into the steppe would not have taken place if the Near East had been hit by disastrous droughts (for an extensive discussion of this matter the reader is referred to Bottema, 1993).

The manifestation of the Beyşehir Occupation phase in the pollen record lasts up to about AD 400. Then its palynological pattern is weakened or even disintegrates. This may be an indication of decreasing human impact but it is also possible that the agrarian system changed towards methods that had a different effect upon the vegetation, resulting in quite another pollen picture.

Grazing affects the vegetation and may lead to a stage in which strongly smelling Labiatae, which are unpalatable for sheep and goat, and so become dominant. Herdsmen will take measures to change such vegetations to benefit their flocks, for instance by burning.

Every animal species has a pronounced preference for a certain habitat and differs to a certain extent in the way it takes the herbal matter by grazing or browsing. However, the ecological range of herbivores is remarkably wide and a certain overlap does exist even under natural conditions. If forced upon the animals, a far more restricted diet is accepted. To illustrate the extreme, one could keep cattle, horses, sheep, pigs and geese in the same meadow covered with *Lolium perenne* only. In practice, however, certain situations are always avoided. Goats, and to a lesser extent sheep, avoid wet conditions, marshes and swamps which are a source of certain diseases for small ruminants. They prefer dry valleys, mountain meadows and goats especially thrive on rocky slopes which are inaccessible to people and where vegetal matter cannot be gathered economically by large herbivores. Yet, there are overlapping areas where both cattle and small ruminants are herded. The same can be said of man-made environments such as fallow and stubble fields.

Crop growing needs the cultivation of arable land and this not only affects the natural vegetation but also disturbs the soil. The surface is opened, ploughed, in younger periods even turned over. As soon as a soil is disturbed, weedy or ruderal vegetations appear that profit from the new conditions. The vegetation that

develops depends upon the properties of the soil, the climatic regime and the kind of crop that is grown. The length of fallow will also determine the plants growing in an arable system.

The most numerous weeds seen in fields in the Near East nowadays in the summer and autumn, after the harvest has taken place, are members of the composite family. *Onopordon* and *Scolymus* can be found in abandoned fields, on the edges of fields and on roadsides where there is much disturbance. Annual relatives of the cornflower, *Centaurea solstitialis* and *C. iberica* (section 7.9.8), are also found in fields, on wasteland, and on roadsides.

The fields themselves show *Matricaria* spec., *Inula* spec. and *Xanthium*. These composite plants are mostly pollinated by insects and their pollen has a modest share (e.g. 3-5% per type) in the modern pollen precipitation. Higher percentages have various, often combined, causes (Bottema & Woldring, 1990):

a. The composite plant may have occurred in large numbers in the vegetation, thus producing large amounts of pollen. Composite pollen (e.g. Liguliflorae) may obtain higher values in surface samples than in samples from lakes or marshes, because the plants may grow very close to the sample, but even in this case their share rarely amounts to more than 5%;

b. The composite pollen is more resistant than other pollen types, which in time disappeared from the sediment through certain agents. This happens where shallow lakes are likely to form sediments that dry up during the summer. Such sediment is oxidized and eventually will be devoid of pollen;

c. The composite pollen was produced under very hot conditions in open fields and was concentrated in the precipitation by air flow. This is explained for the lake of Zirelia in Greece (Bottema & Woldring, 1990).

From the foregoing it could only be concluded that the association of certain composite pollen types with cultivation, as visible in diagrams, must be based on a and c. Large numbers of plants occurred and their pollen was concentrated by meteorological/climatic action in the sediment archive. The high composite pollen value could have been caused by a natural phenomenon, for instance a pronounced continental climate that caused a very open steppe vegetation with hot summers. This makes the composite pollen unfit as indicators of cultivation. The Beyşehir Occupation phase shows a decrease in composite pollen, together with clear indications of human activity. In this case the decrease in composite pollen, especially *Centaurea solstitialis*-type, is explained as having been caused by a climatic change. This explanation would imply that the Beyşehir Occupation phase as it comes to us in the pollen record, bears witness to the exploitation of orchards, the effect of grazing and an increase in moisture. The pollen assemblage does not supply much information on arable cultivation.

Indications of human activity obtained from the

pollen record in northern Turkey after the Beyşehir Occupation phase are weak, but in this weak form they are persistent enough to show that the basic elements of farming were still there. It may be that around AD 400 demographic shifts, as attested for Europe in that time, also took place in Anatolia, given the decreasing anthropogenic indicators in the pollen diagrams. There is also a change in the records that can be explained by dry conditions that were less favourable for human habitation (Bottema & Woldring, 1990).

For the most recent period, the last centuries, most Turkish diagrams show an important increase in pine pollen. In the field, however, pine forest was not seen in amounts that could account for such high pollen percentages. Perhaps pine forest was cleared on a large scale especially during the last centuries. Employees of the State Forestry at Sivas mentioned the presence of extensive *Pinus nigra* forest in the area as resembled by old people. These forests had now disappeared but recently new plantations had been laid out.

In marshes that were not drained, sediment formation and pollen precipitation must have continued up to the present day. In this respect the pollen content of the upper part is of particular interest, but unfortunately these recent years especially could not be documented because of sampling difficulties. Often the record starts at 30 to 60 cm because the topmost, loose part dropped out of the sampler.

The amount of pine pollen increases in the upper part of some records. As this increase of pine pollen cannot be explained by an increase in pine forest it must be the result of a severe reduction of all other pollen, caused by man's destruction of the vegetation. Various types of forest were much reduced and could not regenerate because of constant overgrazing by goats and of soil erosion. The open space potentially occupied by herbs increased enormously, but the pollen production stayed far behind, because the herbs were grazed away by goats and sheep. Some vegetations became dominated by unpalatable species, but these belong to insect-pollinated plants and are not represented in the pollen precipitation. One would expect the modern surface samples to clearly illustrate this explanation by high pine pollen values dominating their spectra.

In Anatolian pollen diagrams the high percentages of *Pinus* already drew the attention of van Zeist and colleagues during the investigations in southwestern Turkey. The pollen record of northern Turkey has been screened for the same phenomenon, both in the top samples of the subfossil records and in the surface samples. The dating of the top samples of pollen cores is a problem. They seldom represent the most recent or present-day pollen precipitation for reasons explained above, but they may represent situations up to a few centuries ago.

From table 4 it can be concluded that pine pollen values may be quite high in the youngest part of the record. The lowlands of the Sakarya area and the delta

Table 4. Value of *Pinus* pollen in the top sample of each diagram and the percentage of *Pinus* pollen in the surface sample from the same location. Pollen sums generally include the same types.

	Depth	Top sample	Surface samples
Abant Gölü	60 cm	51.3	69.2/61.2
Yeniçağa (Beug, 1967)	5 cm	88	44.8
Melen Gölü	60 cm	20.5	17.1
Küçük Akgöl	50 cm	7.5	32.3
Akgöl Adatepe	275 cm	5.2	15.4
Seyfe Gölü	10 cm	14.3	7.3
Tuzla Gölü	5 cm	47	3.7
Kaz Gölü	30 cm	31.8	10.6
Lâdik Gölü	30 cm	33.4	69.2
Demiryurt Gölü	1 cm	78.0	23.3
Büyük Gölü	10 cm	20.9	23.3
Tatlı Gölü	30 cm	36.5	—

of the Kızılırmak and the mountains around Lâdik Gölü have produced only low *Pinus* values for sub-recent times. The records of the higher mountains, Abant and Yeniçağa, have high values, which can be explained by the common occurrence of pine in the vicinity. Of interest are the locations that are barren today and where pines could have occurred lately or are reported to have grown not so long ago. Among these, the saline steppe lakes have a rather bad record with selective destruction of the pollen content. This applies especially to the Seyfe record and to some extent the Tuzla record. Rather unexpectedly, the matching surface samples display low pine pollen values. This leaves us with the two records of Demiryurt Gölü and Büyük Gölü, two young deposits, some 20 km apart. They are found in the intensively cultivated Kızılırmak valley and have high *Pinus* pollen values, whereas the accompanying surface samples have lower percentages. The latter will have more local pollen, which is less well represented in samples deposited in water bodies. The high pine pollen values in both sites can be explained by long-distance transport of pine pollen, but one has to keep in mind that the absolute number of pine pollen transported to these parts of Anatolia is actually the same as in other localities. The apparently high values of *Pinus* are attained because the local pollen in these highly cultivated areas is so sparse.

A clear example of such over-representation due to long-distance transport is the 12% of *Pinus* in a surface sample from the Bouara salt flats in eastern Syria (Gremmen & Bottema, 1991). There is no pine tree within hundreds of kilometres, nor is there any local vegetation on the salt flats. As we have no absolute measures without well-guided long-term experiments, we have to rely on the relative values of the pollen precipitation obtained from the surface samples.

Unexpectedly high *Pinus* values found in records of the last few centuries are not likely to represent vast pine forests that have all disappeared some decades ago. As

such areas are treeless and much cultivated nowadays, the modern pollen from surface samples reflects low local pollen production.

## 9. GENERAL CONCLUSION

The quality and quantity of the information on the vegetation history of northern Turkey differs from location to location. The time span covered by the various records ranges from c. 14,000 years to less than one millennium. Some of the diagrams display hiatuses. Others include parts that show differential destruction of pollen.

The earliest period, the Late Glacial, is represented in a few sites only. For younger periods progressively more information becomes available. The Late Glacial is represented by sites from the northern mountains, Abant, Yeniçağa and Lâdik Gölü. The evidence is in line with that of northwestern Greece and Europe in general. Steppe conditions prevail during this phase, as attested by the presence of pollen of *Artemisia*, *Ephedra* and *Chenopodiaceae*.

The varied flora in Turkey at the end of the Late Glacial found habitats in the highly diverse landscapes in the vast wilderness. Certainly the vegetation had undergone changes during and especially after the harsh conditions of the Pleniglacial. If demanding plants or trees were to survive this period in refuges, these must be found somewhere in Anatolia. In practice long migration routes can be ruled out, given the means of seed dispersal.

The history of many plant and tree species remains hidden for us because their pollen is either not present in the pollen rain or cannot be identified down to the species level. A tree such as *Parrotia persica*, for instance, which still occurred in the Greek Pindus mountains during the last interglacial, may have been found in the northern Turkish mountains up to the Caspian area, where it occurs nowadays. It probably became extinct in Turkey during the early phases of the ice age and maintained itself in the Colchic forest in Iran only. It is not very clear what happened to *Pterocarya*, a relative of the walnut, also growing in the deciduous forest of northern Iran. Rare pollen grains of *Pterocarya* are encountered in samples from Turkey even in those parts where this tree certainly did not occur or does not grow at the moment. *Pterocarya fraxinifolia* is found very locally in Turkey, for instance near Adapazarı, around Zonguldak, in eastern Anatolia and in the area of Adana and Gaziantep (Davis, 1982: vol. 7). *Cedrus libani* and *Pterocarya fraxinifolia* are mentioned as relics by Mayer & Aksoy (1986). *Pterocarya* is palynologically represented in some spectra of Kaz Gölü dated about 2000 BP and younger. Kaz Gölü lies more inland than the present distribution of *Pterocarya* and it is not clear why the pollen appears there. In most other records, also near the present distribution of the tree, the character-

istic pollen was not found and it is doubtful whether the tree occurred naturally in any place in northern Turkey during the Holocene.

The number of trees during the Late Glacial must have been small, as suggested by the pollen values. The behaviour of the birch at Abant Gölü (Bottema, 1990) informs us about the shifting position of the upper tree limit. It is assumed that the light-demanding birch formed the limit at about 1300 m in that period. This indicates that more demanding tree species could not escape Late Glacial dry conditions by moving upward to even higher locations, where it would have been moister. It would have been too cold as well. Thus, such tree species or herbs must have survived those hard times, closer to the Black Sea.

*Betula* is nowadays found in Turkey mostly east of 40°E. The most westerly report is from the volcano Erciyes Dağ at 36°E. Surface samples from all over Turkey demonstrate that most birch pollen comes in by long-distance transport, wind-borne pollen from Europe that may precipitate especially during rainfall.

During Late Glacial times much higher values are found, indicating that the genus *Betula* was found commonly in the western part of northern Turkey from Abant Gölü to Lâdik Gölü. The rising of the temperature during the Late Glacial and early Holocene caused the treeline to move upward. Finally fir and beech outshaded birch in these parts, whereas in more continental eastern Anatolia on higher mountains *Betula* still found the opportunity to grow in small stands. Apart from changing climate, the grazing of domesticated animals at a later stage must have seriously affected the amount of birch. For details on the history of the birch in Turkey, see Bottema (1990).

Most of the expansion of forest after the ice age was in a vertical direction where it conquered the mountains and to the south where forest invaded the steppe. The majority of the tree species did not move to the east or west, as was the case with birch. This was inferred from the stands of *Picea orientalis* that are found east of the area treated in this study. During the past 14,000 years the Oriental spruce did not shift to the part inhabited by Nordmann fir and beech, or vice versa (Bottema, 1986).

The period of c. 10,000-7000 BP is represented by the records of Abant, Yeniçağa and Lâdik Gölü. The sites lie at elevations of 1300 m, 976 m and 800 m, respectively. The first three millennia of the Holocene offer better conditions for the development of forest than the preceding Late Glacial. Initially, pioneers such as *Acer* replace birch forest at the elevation of Lake Abant, but very soon fir forest dominates. The sites of Abant and Yeniçağa are only some 70 km distance apart and this explains the resemblance of their pollen records. Although the soil in the Abant and Lâdik areas is quite similar (Straub, 1988) there is a difference in forest vegetation because no *Abies* is found in the Lâdik area.

The present vegetation of central-Euxinian mountains is drawn schematically by Mayer & Aksoy (1986).

Table 5.

Time in KY	Abant	Yeniçağa	Melen	Küçük	Adatepe	Seyfe	Tuzla	Demiryurt	Büyük	Kaz	Lâdik	Tatlı	Time in KY
0						?							0
1													1
2													2
3													3
4													4
5													5
6													6
7													7
8													8
9													9
10													10
11													11
12													12
13													13
14													14

*Fagus orientalis* is very common nowadays, but during the period from 10,000-7000 BP beech was insignificant in both areas. *Abies* is found near Abant and Yeniçağa but the Lâdik area had a more steppic character with *Artemisia* and *Chenopodiaceae*, deciduous oak and oriental hornbeam. Today Lâdik receives more precipitation than the Abant-Yeniçağa area and the temperature is higher. Differences in evapotranspiration may explain the different vegetation.

Compared with the following millennia there probably was a substantial amount of tall *Juniperus (excelsa)*. The pollen of *Cupressaceae* cannot be identified down to the species level, but the tall species have a better representation in the pollen record than their low relatives. The deciduous species *Carpinus betulus* and *Corylus* were present in reasonable numbers in the coastal mountains but in the area of Kaz Gölü these species may have been absent.

The period of 7000-4000 BP is present in the record of Abant, Yeniçağa, Kaz, Lâdik and Tatlı Gölü (table 5). The general pollen picture suggests a rather stable forest cover, dominated by *Pinus*, and for northern Turkey. The pine forests must have been most common at medium elevations as inferred from the pollen percentages in the various diagrams. Values vary from c. 20% in Abant, to 45% in Yeniçağa, c. 65% in Lâdik, c. 70-40% in Kaz Gölü, to about 40% in Tatlı Gölü on the coast.

From 4000 BP to the present, the pollen picture is not stable and it becomes extremely difficult to observe clear patterns. Human impact, vegetation succession and climate may have played a role but their respective influence is difficult to identify. The records of Melen and Küçük Akgöl can be added to the preceding series. Local effects seem to play a role if one considers the variation in behaviour in the various curves. If any climatic change had a crucial effect, this effect should have appeared simultaneously in the records. If we take

into consideration known historical climatic records from northwestern Europe, Abant Gölü may show a change at 880 BP. The medieval warm period came to an end and in Europe an agro-economical depression set in. Abant received these signals mostly through long-distance pollen transport as not many people were farming locally. The record of Melen at 125 m elevation does not show any change in pollen percentages at an interpolated age of 880 BP. It can be concluded that any climatic signal is overridden by the effects of human impact and the subsequent effect of secondary vegetation.

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Table 6. Percentage of pollen types that occurred less than three times in a record.

#### ABANT GÖLÜ

Spectrum 1, 11.00 cm: *Symphytum*-type 0.2, *Bellis*-type 0.4, *Kentranthus* 0.2;  
 Spectrum 2, 10.85 cm: *Arctium*-type/*Jurinea* 0.3, *Crupina* 0.3, *Ranunculus sceleratus*-type 0.1;  
 Spectrum 3, 10.75 cm: *Symphytum*-type 0.2, *Spinacia*-type 0.2, *Capsella*-type 0.2;  
 Spectrum 4, 10.60 cm: *Heterocaryum* 0.2, *Spinacia*-type 0.5;  
 Spectrum 5, 10.50 cm: *Campanula*-type 0.3, *Arctium*-type/*Jurinea* 0.2, *Bupleurum*-type 0.2;  
 Spectrum 6, 10.40 cm: *Pterocarpus*-type 0.1;  
 Spectrum 7, 10.30 cm: *Carya* 0.2, *Geranium* 0.2;  
 Spectrum 8, 10.10 cm: *Fontanesia* 0.2, *Stachys*-type 0.2;  
 Spectrum 11, 9.80 cm: *Polystichum* 0.3;  
 Spectrum 12, 9.70 cm: *Noaea*-type 0.2, *Majanthemum*-type 0.2, *Anisosciadium*-type 0.2, *Myriophyllum spicatum/verticillatum* 0.2;  
 Spectrum 13, 9.65 cm: *Malus*-type 0.2, *Convolvulus* 0.2, *Ferula*-type 0.2;  
 Spectrum 14, 9.60 cm: *Campanula*-type 0.3, *Cruciferae* 0.3, *Bupleurum*-type 0.3;  
 Spectrum 16, 9.50 cm: *Datura* 0.2;  
 Spectrum 15, 9.55 cm: *Euonymus* 0.3, *Scutellaria* 0.3, *Roemeria dodecandra*-type 0.3;  
 Spectrum 17, 9.40 cm: *Ferula*-type 0.3, *Valerianella* 0.3;  
 Spectrum 18, 9.30 cm: *Cercis* 0.6, *Malus*-type 0.3;  
 Spectrum 19, 9.10 cm: *Asphodeline* 0.2, *Solanum dulcamara* 0.2, *Cryptogramma* 0.2;  
 Spectrum 20, 8.90 cm: *Prunus*-type 0.8;  
 Spectrum 21, 8.70 cm: *Matthiola* 0.3, *Thesium* 0.3;  
 Spectrum 23, 8.45 cm: *Hippocrepis*-type 0.4, *Cryptogramma* 0.4;  
 Spectrum 25, 8.15 cm: *Ononis*-type 0.2, *Solanum dulcamara* 0.2;  
 Spectrum 26, 8.00 cm: *Descurainia* 0.2, *Datura* 0.5;  
 Spectrum 28, 7.60 cm: *Anagallis* 0.3, *Geranium* 0.3;  
 Spectrum 29, 7.40 cm: *Arceuthobium* 0.4, *Myrtus* 0.4, *Primula* 0.4, *Thesium* 0.4, *Anagallis* 0.4;  
 Spectrum 30, 7.20 cm: *Frangula* 0.3, *Cotoneaster* 0.3;  
 Spectrum 32, 6.80 cm: *Majanthemum*-type 0.3;

Spectrum 33, 6.60 cm: *Frangula* 0.4;  
 Spectrum 34, 6.50 cm: *Cyclamen* 0.3;  
 Spectrum 35, 6.25 cm: *Hedera* 0.3, *Spergularia*-type 0.3, *Ranunculus peltatus*-type 0.3;  
 Spectrum 37, 5.90 cm: *Noaea*-type 0.3, *Antirrhinum/Linaria* 0.3;  
 Spectrum 38, 5.70 cm: *Cheilanthes* 0.5;  
 Spectrum 39, 5.50 cm: *Convolvulus* 0.3, *Pimpinella*-type 0.3;  
 Spectrum 40, 5.30 cm: *Gentiana tenella* 0.3, *Gentiana purpurea* 0.6, *Antirrhinum/Linaria* 0.3;  
 Spectrum 42, 4.90 cm: *Pterocarya* 0.3, *Campanula*-type 0.3, *Ranunculus peltatus*-type 0.3;  
 Spectrum 43, 4.70 cm: *Jasione*-type 0.3, *Hypericum perforatum*-type 0.3, *Teucrium* 0.3, *Cyclamen* 0.3, *Selaginella* 0.3;  
 Spectrum 44, 4.50 cm: *Rhynchospora*-type 0.2;  
 Spectrum 45, 4.30 cm: *Rhynchospora*-type 0.2, *Teucrium* 0.2, *Haplophyllum* 0.2, *Rosa*-type 0.2, *Solanum nigrum* 0.2;  
 Spectrum 47, 3.90 cm: *Verbena* 0.2;  
 Spectrum 46, 4.10 cm: *Ligustrum* 0.2;  
 Spectrum 48, 3.70 cm: *Campanula*-type 0.2;  
 Spectrum 51, 3.10 cm: *Rosa*-type 0.2;  
 Spectrum 52, 2.90 cm: *Ligustrum* 0.2, *Juncus/Luzula* 1.1;  
 Spectrum 53, 2.70 cm: *Malva* 0.2, *Ranunculus asiaticus*-type 0.2, *Azolla* 0.6;  
 Spectrum 54, 2.50 cm: *Fontanesia* 0.2, *Onosma*-type 0.2, *Cruciferae* 0.2, *Chelidonium* 0.2;  
 Spectrum 55, 2.30 cm: *Gentiana nivalis*-type 0.2, *Ranunculus sceleratus*-type 0.2;  
 Spectrum 56, 2.15 cm: *Frankenia hirsuta*-type 0.6, *Hypericum perforatum*-type 0.2, *Ononis*-type 0.2, *Utricularia* 0.2;  
 Spectrum 57, 2.00 cm: *Descurainia* 0.2;  
 Spectrum 58, 1.90 cm: *Viola* 0.2;  
 Spectrum 59, 1.70 cm: *Viola* 0.2;  
 Spectrum 61, 1.30 cm: *Fontanesia* 0.2, *Cornus mas* 0.3, *Arceuthobium* 0.1, *Polygonum convolvulus*-type 0.2;  
 Spectrum 62, 1.10 cm: *Primula* 0.1, *Rhinanthus*-type 0.1, *Juncus/Luzula* 0.1;



Spectrum 63, 0.90 cm: *Cuscuta* 0.1, *Rumex hydrolapathum* 0.1, *Rhinanthus*-type 0.1;  
 Spectrum 65, 0.60 cm: *Populus* 0.2;  
 Spectrum 74, 0.70 cm: *Campanula*-type 0.2, *Kentranthus* 0.2.

## YENİÇAĞA

Spectrum 2, 17.00 cm: *Centaurea cyanus*-type 0.4, *Cousinia* 0.6, *Polygonum persicaria*-type 0.2;  
 Spectrum 3, 16.80 cm: *Sambucus nigra*-type 0.2, *Hippophae* 0.2, *Centaurea* 0.8, *Calluna*-type 0.4;  
 Spectrum 4, 16.60 cm: *Urtica* 0.4;  
 Spectrum 6, 16.20 cm: *Turgenia*-type 0.2;  
 Spectrum 7, 16.10 cm: *Centaurea jacea*-type 0.3;  
 Spectrum 8, 16.00 cm: *Gagea*-type 0.8;  
 Spectrum 9, 15.90 cm: *Centaurea cyanus*-type 0.4, *Lobelia* 0.4, *Polygonum convolvulus*-type 0.4;  
 Spectrum 11, 15.75 cm: *Genista*-type 0.8;  
 Spectrum 12, 15.70 cm: *Asanguisorba officinalis* 0.3;  
 Spectrum 13, 15.55 cm: *Pterocarya* 0.8, *Arctium*-type/Jurinea 0.8, *Carduus*-type 0.4, *Tulipa*-type 0.8;  
 Spectrum 15, 15.30 cm: *Carya* 0.2, *Rosa*-type 0.2, *Humulus/Canabis* 0.2, *Hedysarum/Ebenus* 0.2, *Delphinium*-type 0.2;  
 Spectrum 17, 15.00 cm: *Papaver* 0.3, *Potamogeton* 0.9;  
 Spectrum 18, 14.80 cm: *Bupleurum*-type 0.4;  
 Spectrum 19, 14.60 cm: *Saxifraga nivalis*-type 0.4;  
 Spectrum 20, 14.45 cm: *Asanguisorba*-type 0.2, *Hedysarum/Ebenus* 0.2, *Lobelia* 0.2, *Ceratocephalus* 0.2, *Apium*-type 0.2;  
 Spectrum 23, 13.90 cm: *Hedera* 0.2, *Teucrium* 0.2, *Eremurus* 1.1, *Nigella* 0.2, *Ranunculus peltatus*-type 0.4;  
 Spectrum 25, 13.55 cm: *Nigella* 0.5;  
 Spectrum 26, 13.30 cm: *Convolvulus* 0.3, *Lathyrus*-type 0.1, *Potentilla*-type 0.1, *Heracleum*-type 0.3;  
 Spectrum 27, 13.05 cm: *Scrophulariaceae* 0.3;  
 Spectrum 28, 12.80 cm: *Quercus coccifera*-type 0.3;  
 Spectrum 29, 12.70 cm: *Daphne* 0.2, *Scrophulariaceae* 0.2;  
 Spectrum 30, 12.55 cm: *Cedrus* 0.2;  
 Spectrum 31, 12.35 cm: *Cotoneaster* 0.6;  
 Spectrum 32, 11.95 cm: *Artemisia vulgaris*-type 0.5;  
 Spectrum 33, 11.80 cm: *Prunus*-type 0.2, *Cerinthe*-type 0.2, *Gentiana* 0.2;  
 Spectrum 35, 11.50 cm: *Convolvulus* 0.2;  
 Spectrum 36, 11.30 cm: *Loranthus* 0.3;  
 Spectrum 37, 10.95 cm: *Quercus calliprinos*-type 0.4, *Lotus*-type 0.2;  
 Spectrum 38, 10.50 cm: *Centaurea* 0.4, *Plantago media*-type 0.8;  
 Spectrum 40, 9.80 cm: *Polygonum amphibium* 0.4, *Caltha* 0.4;  
 Spectrum 42, 9.30 cm: *Hippocrepis*-type 0.3;  
 Spectrum 43, 8.85 cm: *Helianthemum* 0.3, *Polygonum convolvulus*-type 0.3, *Solanaceae* 0.3;  
 Spectrum 44, 8.50 cm: *Stachys*-type 0.2, *Ononis*-type 0.2, *Pedicularis* 4.2, *Zygophyllum* 0.2, *Ophioglossum* 0.2;  
 Spectrum 45, 8.30 cm: *Castanea* 0.3;  
 Spectrum 46, 7.85 cm: *Helianthemum* 0.2;  
 Spectrum 47, 7.65 cm: *Liliaceae* 0.3, *Aquilegia*-type 0.3, *Pedicularis* 1.3, *Valerianella* 0.3;  
 Spectrum 48, 7.50 cm: *Epipactis* 0.8, *Caltha* 3.8;  
 Spectrum 49, 7.30 cm: *Cotoneaster* 0.2, *Cerinthe*-type 0.2, *Lotus*-type 0.2, *Eryngium*-type 0.2, *Heracleum*-type 0.2;  
 Spectrum 50, 7.05 cm: *Gentiana* 0.3, *Medicago* 0.3, *Plantago tenuiflora*-type 0.3, *Rumex hydrolapathum* 0.3, *Epipactis* 0.3;  
 Spectrum 51, 6.80 cm: *Populus* 0.4, *Digitalis* 0.2;  
 Spectrum 52, 6.50 cm: *Calystegia* 0.2, *Calluna*-type 0.2, *Plantago coronopus*-type 0.2, *Anemone* 0.2, *Menyanthes trifoliata* 4.7;  
 Spectrum 53, 6.30 cm: *Castanea* 0.3, *Onobrychis*-type 0.3;  
 Spectrum 54, 5.80 cm: *Sambucus racemosa*-type 0.2, *Populus* 0.5, *Centaurea scabiosa*-type 0.2;  
 Spectrum 55, 5.30 cm: *Viburnum*-type 0.2.

## MELEN GÖLÜ

Spectrum 1, 14.75 cm: spore trilete 0.1;  
 Spectrum 7, 14.10 cm: *Pterocarya* 0.2, *Crataegus*-type 0.3;  
 Spectrum 8, 14.00 cm: *Periploca* 0.2, *Eryngium*-type 0.2;

Spectrum 9, 13.80 cm: *Cornus sanguinea* 0.1;  
 Spectrum 10, 13.65 cm: *Cuscuta* 0.1, *Menyanthes* 0.1;  
 Spectrum 11, 13.10 cm: *Cistus* 0.1, *Eryngium*-type 0.1;  
 Spectrum 12, 12.90 cm: *Orobanch* 0.1;  
 Spectrum 13, 12.75 cm: *Hedysarum/Ebenus* 0.1;  
 Spectrum 14, 12.40 cm: *Cynocrambe* 0.2, *Botrychium* 0.2;  
 Spectrum 16, 12.00 cm: *Crassulaceae* 0.2;  
 Spectrum 17, 11.85 cm: *Apium*-type 0.1;  
 Spectrum 18, 11.60 cm: *Fontanesia* 0.1, *Kentranthus* 0.1;  
 Spectrum 19, 11.50 cm: *Fontanesia* 0.1;  
 Spectrum 21, 10.95 cm: *Gentiana nivalis*-type 0.2, *Nymphoides* 0.2;  
 Spectrum 22, 10.80 cm: *Hedysarum/Ebenus* 0.2, *Botrychium* 0.2;  
 Spectrum 23, 10.60 cm: *Celtis* 0.1, *Cistus* 0.1, *Punica* 0.1, *Capsella*-type 0.2, *Prunella*-type 0.1;  
 Spectrum 24, 10.40 cm: *Cyclamen* 0.1;  
 Spectrum 28, 9.60 cm: *Lychnis*-type 0.1, *Plantago media*-type 0.1;  
 Spectrum 34, 8.40 cm: *Epilobium* 0.1, *Urtica pilulifera*-type 0.1;  
 Spectrum 35, 8.20 cm: *Lathyrus*-type 0.1, *Calligonum* 0.1;  
 Spectrum 37, 7.80 cm: *Stachys*-type 0.1;  
 Spectrum 38, 7.60 cm: *Lychnis*-type 0.1, *Bupleurum*-type 0.1;  
 Spectrum 39, 7.40 cm: *Periploca* 0.1;  
 Spectrum 40, 7.20 cm: *Liquidambar* 0.1, *Convolvulus* 0.1;  
 Spectrum 41, 7.00 cm: *Labiatae* 0.1, *Bupleurum*-type 0.1;  
 Spectrum 42, 6.90 cm: *Stachys*-type 0.1, *Ranunculaceae* 0.3;  
 Spectrum 44, 6.60 cm: *Geum*-type 0.3, *Antirrhinum/Linaria* 0.2;  
 Spectrum 45, 6.40 cm: *Onobrychis*-type 0.2;  
 Spectrum 47, 6.00 cm: *Cerinthe*-type 0.1;  
 Spectrum 48, 5.75 cm: *Delphinium*-type 0.1;  
 Spectrum 49, 5.60 cm: *Fraxinus orms* 0.1, *Labiatae* 0.1;  
 Spectrum 50, 5.40 cm: *Celtis* 0.2, *Lemna* 0.2;  
 Spectrum 52, 5.00 cm: *Fraxinus orms* 0.1, *Noaea*-type 0.1, *Epilobium* 0.1, *Rumex acetosa*-type 0.1;  
 Spectrum 53, 4.80 cm: *Ephedra distachya*-type 0.1;  
 Spectrum 54, 4.60 cm: *Cotinus* 0.1, *Viscum* 0.1, *Glaucium* 0.1, *Hippurus* 0.1;  
 Spectrum 55, 4.40 cm: *Rumex acetosa*-type 0.1;  
 Spectrum 56, 4.20 cm: *Campanula*-type 0.1, *Glaucium* 0.1, *Menyanthes* 0.1;  
 Spectrum 57, 4.00 cm: *Pyrus* 0.2, *Linum* 0.1, *Kicksia* 0.1;  
 Spectrum 60, 3.40 cm: *Pyrus* 0.1, *Delphinium*-type 0.1;  
 Spectrum 61, 3.20 cm: *Sagittaria* 0.2;  
 Spectrum 62, 3.00 cm: *Ranunculaceae* 0.1, *Consolida* 0.1, *Celsia*-type 0.1;  
 Spectrum 63, 2.80 cm: *Cousinia* 0.1, *Hypecoum* 0.1;  
 Spectrum 64, 2.65 cm: *Hippophae* 0.1, *Iris* 0.1, *Plantago cylindrica*-type 0.1, *Lycopodium* 0.1;  
 Spectrum 65, 2.50 cm: *Myrica* 0.1, *Plantago ovata*-type 0.1;  
 Spectrum 66, 2.35 cm: *Rindera*-type 0.2;  
 Spectrum 67, 2.20 cm: *Viscum* 0.1;  
 Spectrum 69, 1.80 cm: *Capsella*-type 0.1, *Ruta* 0.1;  
 Spectrum 70, 1.60 cm: *Batrachium*-type 0.1;  
 Spectrum 71, 1.40 cm: *Viscum* 0.3, *Oleaceae* 0.1;  
 Spectrum 72, 1.20 cm: *Hippophae* 0.1, *Frangula* 0.1, *Bellis*-type 0.1, *Lepidium* 0.1;  
 Spectrum 73, 1.00 cm: *Malus*-type 0.3, *Tamarix* 0.1, *Crassulaceae* 0.1, *Alhagi* 0.3, *Androsace* 0.1, *Geum*-type 0.6, *Antirrhinum/Linaria* 0.1;  
 Spectrum 74, 0.80 cm: *Gentiana nivalis*-type 0.1, *Corydalis* 0.1, *Plantago maritima*-type 0.1, *Rubus* 0.1;  
 Spectrum 75, 0.70 cm: *Frangula* 0.1, *Alhagi* 0.3, *Plantago major*-type 0.3, *Plantago maritima*-type 0.1, *Lemna* 0.3;  
 Spectrum 76, 0.60 cm: *Oleaceae* 0.1, *Ephedra fragilis*-type 0.1, *Roemeria dodecandra*-type 0.1.

## KÜÇÜK AKGÖL

Spectrum 5, 4.20 cm: *Cnicus* 4.1, *Anagallis* 8.2, *Osmunda* 2.0, *Marsilia* 2.0;  
 Spectrum 6, 4.10 cm: *Scorzonera*-type 0.4, *Cheilanthes* 0.4, spore monolet 1.1;  
 Spectrum 7, 4.00 cm: *Salvinia* 2.2;  
 Spectrum 8, 3.90 cm: *Viburnum*-type 0.4, *Prunus*-type 0.1, *Scorzonera*-

type 0.2, *Cnicus* 0.1, *Knautia* 0.1, Ranunculaceae 0.1, *Ranunculus sceleratus*-type 0.1, *Potentilla*-type 0.1, *Anthriscus*-type 0.1, *Apium*-type 0.1, *Lycopodium* 0.1;  
 Spectrum 9, 3.80 cm: *Acer* 0.2, *Buxus* 0.1, *Picea* 0.1, *Teucrium* 0.1, *Lilium* 0.1, *Hydrocharis* 0.1;  
 Spectrum 10, 3.60 cm: *Linum* 0.2;  
 Spectrum 11, 3.40 cm: *Knautia* 0.7, *Gentiana* 0.2, *Sideritis* 0.2, *Lycopodium* 0.2;  
 Spectrum 12, 3.20 cm: Rhamnaceae 0.2;  
 Spectrum 13, 3.00 cm: *Spiraea* 0.2, *Centaurea jacea*-type 0.2, *Anagallis* 0.6, *Delphinium*-type 0.2, *Ranunculus sceleratus*-type 0.4, *Alchemilla* 0.2, *Antirrhinum/Linaria* 0.9, *Anthriscus*-type 0.2;  
 Spectrum 14, 2.80 cm: *Daphne* 0.2, *Filipendula* 0.2, *Rhinanthus*-type 0.2, *Turgenia*-type 0.2;  
 Spectrum 15, 2.60 cm: *Noaea*-type 0.2, *Urtica pilulifera*-type 0.2;  
 Spectrum 16, 2.45 cm: *Buxus* 0.2, *Capsella*-type 0.2, *Ephedra fragilis*-type 0.4, Labiatae 0.2, Scrophulariaceae 0.2, *Urtica dioica*-type 0.2;  
 Spectrum 17, 2.30 cm: *Taxus* 0.2, *Datisca* 0.2, *Rumex hydrolapathum* 0.2, *Geum*-type 0.2, *Nuphar* 0.2;  
 Spectrum 18, 2.15 cm: *Paliurus* 0.7, *Rosa*-type 0.7, *Vitex* 0.3, *Spergularia*-type 0.3, Labiatae 0.3, *Astragalus*-type 0.3, *Lathyrus*-type 0.7, *Asparagus*-type 0.3, *Potentilla*-type 0.7, *Ferula*-type 0.3, *Verbena* 1.7, *Lemna* 0.3;  
 Spectrum 19, 2.00 cm: *Acer* 0.4, *Arceuthobium* 0.4, *Picea* 0.4, *Geum*-type 0.7, *Marsilia* 0.4;  
 Spectrum 21, 1.60 cm: *Sambucus ebulus* 0.2, *Osmanthus* 0.3, *Echium*-type 0.2, *Hypericum perforatum*-type 0.2, *Hedysarum/Ebenus* 0.5, *Lathyrus*-type 0.2, Ranunculaceae 0.3, *Celsia*-type 0.2, *Veronica* 0.2, *Selaginella* 0.2, *Verbena* 0.3;  
 Spectrum 22, 1.40 cm: *Cornus mas* 0.2, *Heliotropium*-type 0.2, *Capsella*-type 0.2;  
 Spectrum 23, 1.20 cm: *Datisca* 0.2;  
 Spectrum 24, 1.00 cm: *Malus*-type 0.2, Liliaceae 0.2;  
 Spectrum 25, 0.80 cm: *Hippocrepis*-type 0.2, *Polygonum cognatum*-type 0.2, Rosaceae 0.2;  
 Spectrum 26, 0.50 cm: *Cornus mas* 0.1, *Sparganium*-type 0.4.3.

## SEYFE GÖLÜ

Spectrum 1, 2.60 cm: *Alnus* 2.2, *Betula* 4.4, *Carpinus betulus* 1.1, *Corylus* 6.7, *Ostrya/Carpinus orientalis* 2.2, *Fagus* 3.3, *Crataegus*-type 1.1, Caryophyllaceae 2.2, *Centaurea solstitialis*-type 2.2, *Matricaria*-type 1.1, Cerealia-type 1.1, *Trifolium*-type 1.1, *Delphinium*-type 1.1, *Galium*-type 1.1, *Apium*-type 1.1, *Bunium*-type 1.1, *Heracleum*-type 2.2, *Myriophyllum spicatum/verticillatum* 27.8, *Pteridium* 1.1, *Salvinia* 8.9, spore trilete 1.1;  
 Spectrum 2, 1.30 cm: *Salix* 0.5, *Urtica dioica*-type 0.5, *Sphagnum* 0.5, spore trilete 0.5;  
 Spectrum 5, 1.00 cm: *Ilex* 0.2, Leguminosae 0.2, Ranunculaceae 0.2;  
 Spectrum 6, 0.80 cm: *Salix* 0.4, *Polygonum aviculare*-type 0.6, *Rumex acetosa*-type 0.2, *Veronica* 0.2;  
 Spectrum 7, 0.50 cm: *Urtica dioica*-type 0.1;  
 Spectrum 8, 0.10 cm: *Cedrus* 0.7, *Plantago lanceolata*-type 4.9, *Nigella* 0.3.

## TUZLA GÖLÜ

Spectrum 1, 3.81 cm: *Acer* 0.1, *Pistacia* 0.1, *Carpinus betulus* 0.3, *Fagus* 0.1, *Salix* 0.1, *Artemisia vulgaris*-type 0.3, *Ephedra fragilis*-type 0.1, *Geranium* 16.4, Liliaceae 0.1, Plantaginaceae 0.1, *Plantago media*-type 0.6, *Adonis* 0.2, *Pteridium* 0.3, *Ophioglossum* 0.1, *Equisetum* 0.1;  
 Spectrum 2, 3.67 cm: *Fagus* 0.1, *Quercus calliprinos*-type 0.1, *Fraxinus ornus* 0.1;  
 Spectrum 3, 3.36 cm: *Pistacia* 0.2, *Noaea*-type 0.2, Ericaceae 0.2, *Teucrium* 0.4;  
 Spectrum 4, 3.00 cm: *Convolvulus* 0.4, *Ranunculus asiaticus*-type 0.4;  
 Spectrum 5, 2.90 cm: *Teucrium* 0.7;  
 Spectrum 6, 2.50 cm: Cruciferae 0.2;  
 Spectrum 7, 2.00 cm: *Ephedra fragilis*-type 1.2;  
 Spectrum 10, 1.40 cm: *Cousinia* 0.5;

Spectrum 11, 1.30 cm: *Carpinus betulus* 0.3, *Juglans* 0.3, *Heliotropium*-type 0.3, *Hypericum perforatum*-type 0.6, *Haplophyllum* 0.3;  
 Spectrum 12, 0.80 cm: *Ranunculus sceleratus*-type 0.6, *Filipendula* 0.2;  
 Spectrum 13, 0.60 cm: *Vitis* 0.2, Cruciferae 2.0;  
 Spectrum 14, 0.20 cm: Scrophulariaceae 0.2, *Rhinanthus*-type 0.2;  
 Spectrum 15, 0.10 cm: *Centaurea scabiosa*-type 0.2, *Rhinanthus*-type 0.2, *Potamogeton* 0.8;  
 Spectrum 16, 0.05 cm: *Punica* 0.1, *Artemisia vulgaris*-type 0.3, *Cuscuta* 0.3, *Ephedra distachya*-type 0.1, *Thymus/Mentha*-type 0.3, *Asphodelus* 0.3, *Plantago coronopus*-type 0.3, *Ranunculus repens*-type 0.1, *Thalictrum* 0.1, *Filipendula* 0.1.

## DEMIRYURT GÖLÜ

Spectrum 1, 3.62 cm: *Asperula*-type 0.2, *Bupleurum*-type 0.5;  
 Spectrum 2, 3.50 cm: *Fraxinus excelsior* 0.2, *Onopordon*-type 0.2, *Sideritis* 0.4, *Lotus*-type 0.2, *Onobrychis*-type 0.2, *Vicia*-type 0.2, *Plantago media*-type 0.2, *Aquilegia*-type 0.2, *Ranunculus arvensis* 0.2, *Filipendula* 0.2, *Scrophularia/Verbascum*-type 0.2;  
 Spectrum 3, 3.30 cm: *Artemisia vulgaris*-type 0.5, *Dipsacus*-type 1.0, *Sisyrinchium* 0.5, *Potentilla*-type 0.5, Scrophulariaceae 0.5, *Myriophyllum spicatum/verticillatum* 0.5;  
 Spectrum 4, 2.90 cm: *Symphytum*-type 0.3, *Littorella*-type 0.3, *Pimpinella*-type 0.3;  
 Spectrum 5, 2.80 cm: *Triglochin* 0.7;  
 Spectrum 6, 2.70 cm: *Campanula*-type 0.6, *Scrophularia/Verbascum*-type 0.6, *Isoetes* 1.7;  
 Spectrum 7, 2.60 cm: Rhamnaceae 0.3, *Populus* 0.3, *Anchusa/Pulmonaria*-type 0.3, *Echium*-type 0.3, *Scilla*-type 1.3, *Rumex patientia*-type 0.3, *Potentilla*-type 0.3, *Solanum nigrum* 0.5, *Bunium*-type 0.8, *Valeriana* 0.3, *Malabaila* 0.3;  
 Spectrum 8, 2.50 cm: *Echium*-type 0.8, *Hippuris* 34.7;  
 Spectrum 9, 2.30 cm: *Typha latifolia* 0.2;  
 Spectrum 10, 2.00 cm: *Fraxinus excelsior* 0.2, *Onopordon*-type 0.7, *Hypericum perforatum*-type 0.2;  
 Spectrum 11, 1.80 cm: *Cotinus* 0.4, *Xanthium* 0.4, *Ophioglossum* 0.4;  
 Spectrum 12, 1.60 cm: *Matthiola* 0.2, *Scabiosa palaestina*-type 0.2, *Ephedra distachya*-type 0.2, *Thalictrum* 0.2, *Urtica pilulifera*-type 0.2;  
 Spectrum 13, 1.50 cm: Rhamnaceae 0.3, *Anchusa/Pulmonaria*-type 0.3, *Plantago ovata*-type 0.6, *Asperula*-type 0.3, *Trapa natans* 0.2, *Sphagnum* 0.3;  
 Spectrum 14, 1.40 cm: *Acanthus* 0.4, Crassulaceae 0.4, *Dipsacus*-type 0.4, *Geranium* 0.4, *Polygonum persicaria*-type 0.4, *Delphinium*-type 0.4, *Rhinanthus*-type 0.4, *Bunium*-type 0.4;  
 Spectrum 15, 1.30 cm: *Scabiosa palaestina*-type 0.3, *Ephedra fragilis*-type 0.5;  
 Spectrum 16, 1.20 cm: *Noaea*-type 0.6;  
 Spectrum 17, 1.00 cm: *Teucrium* 0.6, *Rhinanthus*-type 0.2;  
 Spectrum 18, 0.90 cm: Cruciferae 0.5, *Geranium* 0.2, *Hedysarum/Ebenus* 1.2, *Filipendula* 0.2, *Veronica* 2.4, *Malabaila* 0.3, *Pimpinella*-type 0.2, *Nitraria* 0.2, *Batrachium*-type 0.2;  
 Spectrum 19, 0.70 cm: *Polypodium* 0.3;  
 Spectrum 20, 0.50 cm: *Urtica dioica*-type 0.1;  
 Spectrum 21, 0.40 cm: *Arctium*-type/Jurinea 0.2;  
 Spectrum 22, 0.20 cm: Crassulaceae 0.1;  
 Spectrum 23, 0.10 cm: *Paracarya*-type 0.1, *Ephedra fragilis*-type 0.1, *Teucrium* 0.1, *Scilla*-type 0.9, *Aquilegia*-type 0.4, *Solanum nigrum* 0.1;  
 Spectrum 24, 0.01 cm: *Aellenia*-type 0.1, *Centaurea scabiosa*-type 0.1, Cruciferae 0.1, *Glaux* 0.3, Ranunculaceae 0.1, *Anisosciadium*-type 0.1.

## KAZ GÖLÜ

Spectrum 1, 9.10 cm: *Vicia*-type 0.6, *Bupleurum*-type 0.3;  
 Spectrum 2, 9.00 cm: *Rhamnus* 0.2, *Cousinia* 0.2, *Erodium* 0.5, *Malabaila* 0.2;  
 Spectrum 3, 8.90 cm: *Cynocrambe* 0.2, *Cryptogramma* 0.2;  
 Spectrum 4, 8.70 cm: *Crupina* 0.1, *Polygonum persicaria*-type 0.1, *Ranunculus arvensis*-type 0.1;  
 Spectrum 5, 8.50 cm: *Sphagnum* 0.2;  
 Spectrum 6, 8.20 cm: *Cousinia* 0.3, *Pistacia* 0.3, *Aesculus* 0.3, *Stachys*

type 0.3, *Fagopyrum* 0.3, *Potentilla*-type 0.3;  
 Spectrum 7, 8.05 cm: *Malcolmia* 0.1, *Prunella*-type 0.1, *Polygonum persicaria*-type 0.2;  
 Spectrum 8, 7.80 cm: *Pterocarpus*-type 0.2;  
 Spectrum 9, 7.70 cm: *Crozophora* 0.2, *Anthoceros laevis*-type 0.2;  
 Spectrum 10, 7.50 cm: *Daphne* 0.2, *Aristolochia* 0.2;  
 Spectrum 11, 7.40 cm: *Datisca* 0.2;  
 Spectrum 12, 7.20 cm: *Cyclamen* 0.7;  
 Spectrum 13, 7.00 cm: *Hibiscus* 0.5;  
 Spectrum 15, 6.60 cm: *Daphne* 0.2;  
 Spectrum 17, 6.20 cm: *Cistus* 0.2;  
 Spectrum 18, 6.00 cm: *Punica* 0.3, *Potentilla*-type 0.1, *Rhinanthus*-type 0.1;  
 Spectrum 20, 5.60 cm: *Populus* 0.2, *Clematis*-type 1.9;  
 Spectrum 21, 5.40 cm: *Juniperus sabina* 0.1, *Ericaceae* 0.1;  
 Spectrum 22, 5.20 cm: *Acer* 0.1;  
 Spectrum 23, 5.00 cm: *Apium*-type 0.3;  
 Spectrum 25, 4.60 cm: *Aesculus* 0.4;  
 Spectrum 26, 4.45 cm: *Menyanthes* 0.1;  
 Spectrum 27, 4.30 cm: *Acanthus* 0.1, *Linum* 0.1, *Rhynchospora*-type 0.1, *Polypodium* 0.1;  
 Spectrum 28, 4.15 cm: *Elaeagnus* 0.1, *Tamarix* 0.1, *Crozophora* 0.2, *Vicia*-type 0.1, *Fumaria* 0.1, *Plantago maritima*-type 0.5, *Lysimachia* 0.1;  
 Spectrum 29, 4.00 cm: *Campanula*-type 0.1, *Prunella*-type 0.1, *Lupinus* 0.1, *Plantago tenuiflora*-type 0.1, *Androsace* 0.1, *Clematis*-type 0.2, *Zygophyllum* 0.2;  
 Spectrum 30, 3.80 cm: *Crataegus*-type 0.1, *Campanula*-type 0.1, *Scorzonera*-type 0.1, *Onobrychis*-type 0.1, *Adonis* 0.2, *Polypodium* 0.1;  
 Spectrum 31, 3.65 cm: *Ligustrum* 0.2, *Ranunculus arvensis*-type 0.2, *Heracleum*-type 0.2;  
 Spectrum 32, 3.50 cm: *Hedera* 0.2, *Aristolochia* 0.2, *Cistus* 0.5, *Echinops* 0.2, *Plantago tenuiflora*-type 0.2, *Bupleurum*-type 0.2;  
 Spectrum 33, 3.20 cm: *Ranunculus asiaticus*-type 0.3, *Rhinanthus*-type 0.3, *Apium*-type 0.3;  
 Spectrum 34, 3.00 cm: *Centaurea spec.* 0.3, *Pteris* 0.3;  
 Spectrum 35, 2.85 cm: *Armeria/Limonium* 0.3, *Salvinia* 0.3;  
 Spectrum 36, 2.65 cm: *Sideritis* 0.8;  
 Spectrum 37, 2.50 cm: *Calluna*-type 0.2;  
 Spectrum 40, 2.00 cm: *Urtica dioica*-type 0.1;  
 Spectrum 41, 1.85 cm: *Plantago maritima*-type 0.1, *Armeria/Limonium* 0.3, *Fagopyrum* 0.3, *Adonis* 0.3, *Heracleum*-type 0.1, *Myriophyllum spicatum/verticillatum* 0.7;  
 Spectrum 42, 1.70 cm: *Punica* 0.3, *Spinacia*-type 0.3, *Circaea* 0.3;  
 Spectrum 43, 1.55 cm: *Euonymus* 0.2, *Arctium*-type/Jurinea 0.2, *Hypericum perforatum*-type 0.2;  
 Spectrum 45, 1.20 cm: *Erodium* 0.2;  
 Spectrum 46, 1.00 cm: *Plantago media*-type 0.1, *Sphagnum* 0.1;  
 Spectrum 47, 0.85 cm: *Zea mays* 0.1, *Anthyllis*-type 0.1;  
 Spectrum 48, 0.70 cm: *Humulus/Cannabis* 0.2, *Cuscuta* 0.2, *Urtica dioica*-type 0.2;  
 Spectrum 49, 0.50 cm: *Cruciferae* 0.4;  
 Spectrum 50, 0.30 cm: *Spergularia*-type 0.3, *Ranunculus asiaticus*-type 0.3.

#### LÂDIK GÖLÜ

Spectrum 1, 8.20 cm: *Cheilanthes* 0.2, *Botrychium* 0.2, *Isoetes* 0.2;  
 Spectrum 2, 8.10 cm: *Spinacia*-type 0.4, *Cousinia* 0.2, *Erodium* 0.2, *Scilla*-type 0.1, *Cryptogramma* 0.1;  
 Spectrum 4, 7.85 cm: *Geum*-type 0.2, *Asperula*-type 0.2, *Caltha* 0.2;  
 Spectrum 5, 7.70 cm: *Aristolochia* 3.0;  
 Spectrum 6, 7.50 cm: *Sarothamnus* 0.2, *Aellenia*-type 0.5, *Onobrychis*-type 0.5, *Papaver* 0.2, *Adonis aestivalis* 0.2, *Caltha* 0.5;  
 Spectrum 7, 7.40 cm: *Herniaria*-type 0.2, *Centaurea scabiosa*-type 0.2, *Onobrychis*-type 0.2;  
 Spectrum 8, 7.10 cm: *Prosopis* 0.4, *Hydrocharis* 0.4;  
 Spectrum 9, 6.80 cm: *Utricularia* 0.6;  
 Spectrum 10, 6.60 cm: *Polygonum amphibium* 1.0;  
 Spectrum 11, 6.30 cm: *Batrachium*-type 0.6;  
 Spectrum 12, 5.55 cm: *Pterocarya* 0.1, *Cynocrambe* 0.1;

Spectrum 13, 5.40 cm: *Daphne* 0.2, *Gentiana vernalis*-type 0.2, *Nepeta* 0.2;  
 Spectrum 14, 5.35 cm: *Calendula* 0.4, *Teucrium* 0.2;  
 Spectrum 15, 5.30 cm: *Larix* 0.2, *Noaea*-type 0.2, *Bellis*-type 0.2, *Cousinia* 0.4, *Linum* 0.2, *Rheum* 0.2, *Verbena* 0.2;  
 Spectrum 16, 5.25 cm: *Anemone* 0.3, *Pimpinella*-type 0.1;  
 Spectrum 17, 5.20 cm: *Bellis*-type 0.2, *Anemone coronaria* 0.2, *Hydrocharis* 0.2;  
 Spectrum 18, 5.05 cm: *Linum* 0.2, *Ranunculus acris* 0.4, *Cheilanthes* 0.2;  
 Spectrum 19, 4.95 cm: *Cnicus* 0.3;  
 Spectrum 23, 4.35 cm: *Scilla*-type 0.4, *Androsace* 0.2;  
 Spectrum 24, 4.20 cm: *Cynocrambe* 0.3;  
 Spectrum 25, 4.00 cm: *Alliagi* 0.3;  
 Spectrum 26, 3.90 cm: *Arceuthobium* 0.2, *Salvinia* 0.2;  
 Spectrum 27, 3.75 cm: *Scutellaria* 0.2, *Papaver* 0.5, *Ranunculus asiaticus*-type 0.2, *Pimpinella*-type 0.2, *Rhynchospora*-type 0.3, *Polygonum amphibium* 0.2, *Salvinia* 0.2;  
 Spectrum 28, 3.60 cm: *Ligustrum* 0.2, *Calligonum* 0.2, *Consolida* 0.2;  
 Spectrum 29, 3.45 cm: *Cuscuta* 0.2, *Urtica pilulifera*-type 0.2;  
 Spectrum 31, 3.15 cm: *Gentiana nivalis*-type 0.2, *Marrubium* 0.2, *Laurus* 0.2, *Alliagi* 0.2, *Linaria* 0.2;  
 Spectrum 34, 2.70 cm: *Periploca* 0.1, *Astragalus*-type 0.1;  
 Spectrum 35, 2.60 cm: *Celtis* 0.6;  
 Spectrum 36, 2.45 cm: *Nepeta* 0.3;  
 Spectrum 37, 2.30 cm: *Astragalus*-type 0.3, *Turgenia*-type 0.5;  
 Spectrum 39, 2.00 cm: *Ranunculus arvensis* 0.4;  
 Spectrum 40, 1.85 cm: *Araceae* 0.3, *Silene*-type 0.1, *Heliotropium*-type 0.1, *Calligonum* 0.1, *Osmunda* 0.1;  
 Spectrum 41, 1.70 cm: *Rosa*-type 0.1;  
 Spectrum 42, 1.65 cm: *Cerinthe*-type 0.1;  
 Spectrum 43, 1.55 cm: *Sorbus*-type 0.1;  
 Spectrum 44, 1.40 cm: *Noaea*-type 0.1, *Gentiana nivalis*-type 0.1;  
 Spectrum 45, 1.25 cm: *Rhynchospora*-type 0.1;  
 Spectrum 46, 1.10 cm: *Frankenia* 0.2, *Verbena* 0.2;  
 Spectrum 49, 0.70 cm: *Morus* 0.3, *Malus*-type 0.3, *Casuarina* 0.3, *Plantago major*-type 0.3;  
 Spectrum 50, 0.60 cm: *Aesculus* 0.1, *Punica* 0.1, *Rhamnus* 0.1, *Ricinus* 0.1, *Secale* 0.1, *Sideritis* 0.1, *Colutea* 0.1, *Phaseolus* 0.2, *Plantago major*-type 0.2, *Cyclamen* 0.1, *Actaea* 0.2, *Veronica* 0.1, *Ranunculus peltatus*-type 0.3, *Cryptogramma* 0.1;  
 Spectrum 51, 0.45 cm: *Myrtus* 0.2, *Rhamnus* 0.2, *Sorbus*-type 0.2, *Cuscuta* 0.2, *Lathyrus*-type 0.2, *Psoralea* 0.2, *Cyclamen* 0.2, *Ranunculus peltatus*-type 0.5;  
 Spectrum 52, 0.30 cm: *Ranunculus arvensis* 0.3, *Isoetes* 0.6.

#### TATLI GÖLÜ

Spectrum 3, 8.80 cm: *Ranunculus asiaticus*-type 0.7, *Nymphaea* 0.7;  
 Spectrum 5, 8.07 cm: *Scrophulariaceae* 0.6;  
 Spectrum 6, 7.60 cm: *Ranunculus asiaticus*-type 0.3, *Nymphaea* 0.3, *Lycopodium* 0.7;  
 Spectrum 7, 7.20 cm: *Plantago media*-type 0.4;  
 Spectrum 8, 6.35 cm: *Phillyrea angustifolia* 0.3, *Humulus/Cannabis* 0.1, *Potamogeton* 0.4;  
 Spectrum 9, 5.50 cm: *Datisca* 0.2, *Potentilla*-type 0.2, *Haplophyllum* 0.2, *Menyanthes* 0.2;  
 Spectrum 10, 5.40 cm: *Loranthus* 0.1, *Echinops* 0.1, *Caltha* 0.1;  
 Spectrum 11, 5.30 cm: *Pteropyrum* 0.2, *Datisca* 0.2, *Glaucium* 0.2, *Scrophularia/Verbascum*-type 0.2;  
 Spectrum 12, 5.20 cm: *Symphytum*-type 0.2, *Sagittaria* 0.2, *Potamogeton* 0.20;  
 Spectrum 13, 3.80 cm: *Scrophularia/Verbascum*-type 0.1;  
 Spectrum 14, 3.40 cm: *Crataegus*-type 0.1, *Heliotropium*-type 0.1, *Cuscuta* 0.1, *Linum* 0.1, *Plantago media*-type 0.3, *Pteropyrum* 0.1, *Scrophulariaceae* 0.1;  
 Spectrum 15, 2.95 cm: *Echium*-type 0.2, *Cuscuta* 0.2, *Valerianella* 0.2;  
 Spectrum 16, 2.75 cm: *Echinops* 0.4, *Filago*-type 0.4, *Crozophora* 0.4, *Fumaria* 0.4, *Polygonum persicaria*-type 0.4, *Anemone spec.* 0.4, *Hyoscyamus* 0.4, *Anisoscadium*-type 0.4;  
 Spectrum 17, 2.55 cm: *Viburnum*-type 0.3, *Matthiola* 0.4, *Scabiosa*

*palaestina*-type 0.3, *Teucrium* 0.3, *Turgenia*-type 0.3;  
Spectrum 18, 2.35 cm: *Aesculus* 0.1, *Humulus/Cannabis* 0.1, Labiatae  
0.1, *Sanguisorba officinalis* 0.1, *Bupleurum*-type 0.1, *Osmunda* 0.1;  
Spectrum 19, 1.95 cm: *Matthiola* 0.6, *Isoetes* 0.2;  
Spectrum 21, 1.73 cm: *Urtica pilulifera*-type 0.3;  
Spectrum 22, 1.00 cm: *Pterocarya* 0.3, *Filago*-type 0.3, *Ephedra*  
*distachya*-type 0.3, *Ruta* 0.3;

Spectrum 23, 0.80 cm: *Xanthium* 0.5, *Polygonum persicaria*-type 0.5;  
Spectrum 24, 0.40 cm: *Phyteuma*-type 0.2;  
Spectrum 25, 0.30 cm: *Pterocarya* 0.1, *Crataegus*-type 0.1, *Sper-*  
*gularia*-type 0.1, *Zea mays* 0.1;  
Spectrum 26, 0.20 cm: *Stachys*-type 0.1.