LATE QUATERNARY VEGETATION AND CLIMATE OF SOUTHWESTERN TURKEY

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CONTENTS

1. INTRODUCTION

In this paper the results will be discussed of the palynological examination of surface samples and sediments cores from southwestern Turkey. This investigation forms part of a larger project comprising the study of Late Quaternary vegetation and climate in the Near East. So far, within the scope of this project, surface-sample spectra and pollen diagrams prepared for sediment cores from western Iran, southeastern Turkey and northwestern Syria have been published (Niklewski & Van Zeist 1970, Wright *et al.* 1967, Van Zeist 1967, Van Zeist *et al.* (1968) 1970, Van Zeist & Wright 1963). Other Late Quaternary pollen diagram sites in the Near East are shown in fig. 1.

One of the aims of the project mentioned above consists of the reconstruction of the environment of prehistoric man in the Late Quaternary which includes the last glacial period and the Postglacial. As a matter of fact, the impetus for this study came from the archaeologists, in particular from Professor Robert J. Braidwood and co-workers. The great emphasis which is presently laid on the environment in the study of prehistoric man requires a satisfactory knowledge of the vegetation in earlier times. Moreover it may be remembered that in Late Quaternary times, more precisely in the period around 10,000 years ago, a very important development took place in the Near East. It was during that period that food production, *i.e.* animal breeding and plant growing, started. The question has been raised as to how far changes in climate and vegetation have stimulated the evolution of food production.

In connection with the above we considered including in this paper a survey of prehistoric and

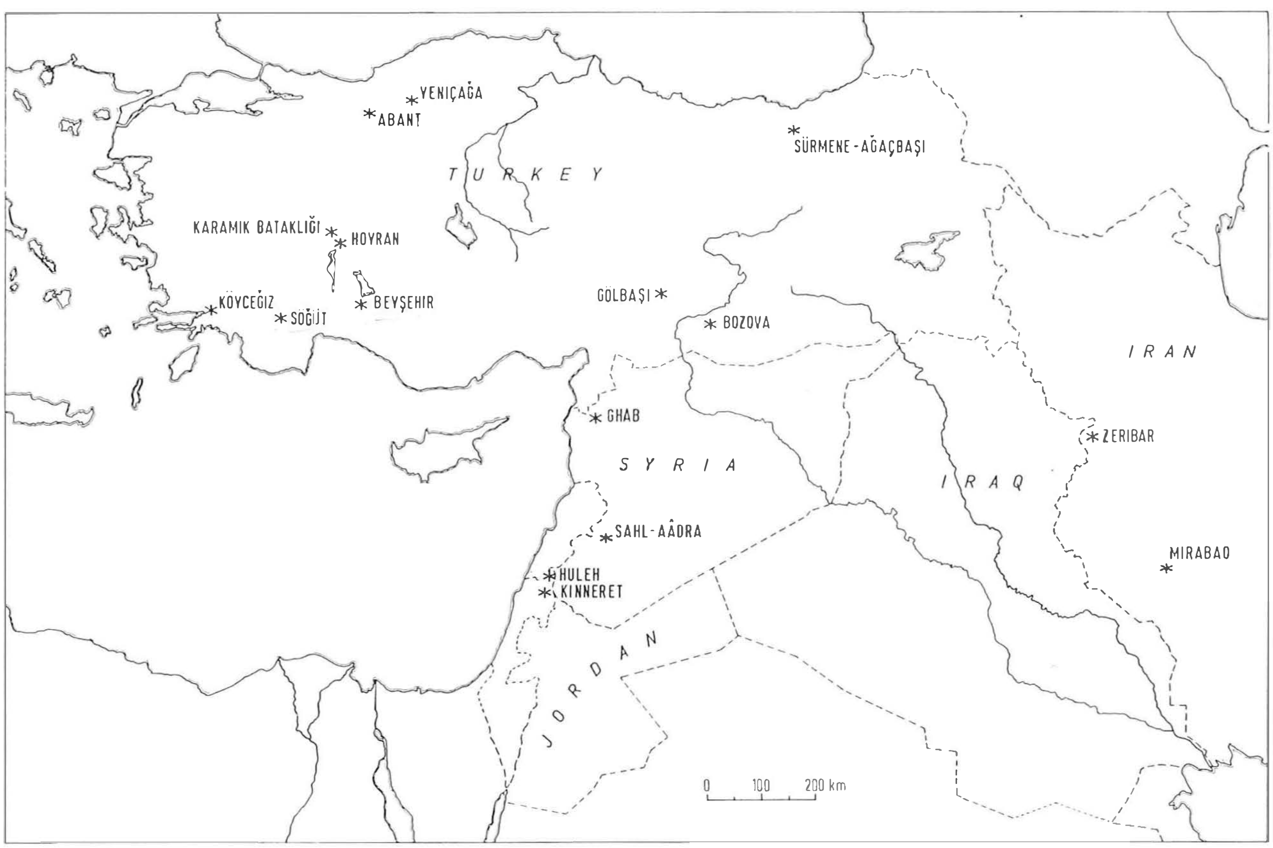

Fig. 1. Map of the Near East showing the location of Late Quaternary pollen-diagram sites. Mirabad and Zeribar: Van Zeist (1967); Bozova and Gölbaşi: Van Zeist *et al.* ((1968) 1970); Surmene-Agaçbaşi: Aytug *et al.* (1973); Yeniçaga and Abant: Beug (1967b); Ghab: Niklewski & Van Zeist (1970); Sahl-Aâdra: Kaiser *et al.* (1973); Huleh and Kinneret: Horowitz (1971). The sites in southwestern Turkey will be discussed in this paper (chapter 7).

early historic man in southwestern Turkey during the last 20,000 years, which time span is covered by the pollen diagrams to be discussed in chapter 7. This was to provide a basis for establishing possible relationships between habitation pattern and vegetation and climate in earlier times. In particular where the activity of man finds expression in the pollen record one would very much like to know which archaeological culture is involved. However, the drawing up of such a survey would have delayed the publication of the palynological results quite considerably. For that reason this plan was given up.

The field work was carried out by W. van Zeist and D. Stapert in May and June 1970. H. Woldring performed the analyses published in this paper.

This investigation and its publication would not have been possible without the cooperation of various people. Dr. S. Alpan, Director-General of the Maden Tetkik ve Arama Enstitüsü (M.T.A.) at Ankara, kindly gave permission for the coring expedition. Dr. Alpan and Dr. Ali Dramali, vice Director-General of the M.T.A., provided all possible facilities for the field work.

Mr. Şevket Şen joined the expedition as the representative of the M.T.A. He acted as interpreter and he paved the way with the local and regional authorities. In addition, he took a substantial part in the hard work of the coring.

Professor Halet Çambel (Istanbul) made great efforts to get the expedition started. It was thanks to her perseverance that the initial difficulties could be smoothed away.

Professor Robert J. Braidwood (Chicago) not only encouraged the present study, but he provided also a financial basis for the coring expedition by incorporating it in the Research project "Continued Investigations of the Late Prehistory and Palaeoenvironments of Southwestern Asia".

The radiocarbon determinations were carried out under the direction of Dr. W. G. Mook. Dr. S. Bottema rendered assistance in identifying pollen types and he critically read the manuscript. Professor P. H. Davis (Edinburgh) provided information on the distribution of some plant species in Turkey.

Mr. W. J. Dijkema and Mr. H. R. Roelink prepared the drawings, and Miss A. Oostwouder typed the manuscript. The English text was improved by Mr. C. van der Meulen and Mrs. B. M. van der Meulen-Melrose (Roden).

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To all who cooperated in this study and in the preparation of the publication the authors wish to express their sincere gratitude.

2. THE GEOLOGY

2.1. *THE WESTERN TAURUS*

2.1.1. INTRODUCTION

The sediment cores, the palynological examination of which will be discussed in this paper, originate from the Western Taurus Mountains (fig. 10). The Taurus forms part of the Alpine mountain belt which, in broad outline, is composed of two more or less parallel mountain ranges (see Holmes 1966, fig. 105). Where these two ranges diverge, large basins or plateaus are found, such as the Aegean basin and the Anatolian plateau. To the north of the Anatolian plateau, the North Anatolian Mountains and the Ziğana Mountains are situated; to the south, the Taurus Mountains.

Louis (1939) divided the Taurus into Eastern, Middle and Western Taurus. His Western Taurus does not comprise the same mountains as the "Westlicher Tauros" of Phillipson (1918) or the "Taurus Occidental" of Blumenthal (1947). Following Brunn *et al.* (1971), in this paper the term Western Taurus is used for the mountains between Anamur in the east and Muğla in the west.

Like the Alpine belt as a whole, individual mountain ranges also consist of wide and narrow parts. Especially in the broader parts intramontane basins are present. Lakes have formed in basins with insufficient drainage.

2.1.2. STRUCTURE OF THE WESTERN TAURIDS

The Western Taurids form an impressive mountain mass with several peaks above 3,000 m. This mountain range is characterized by the fact that, in the western part, the strikes of the individual chains are not parallel to the mountain range as a whole, but approximately perpendicular to it. To the east of the line Antalya-Isparta, NW-SE strikes, parallel to the mountain range as a whole, are predominant. On the other hand, in the Lycian Taurus, NE-SW directions are found. This phenomenon has to do with a complicated orogenic structure in this area, which has been termed the "Courbure d'Isparta". The presence of important *nappe* systems (overthrusted folds) is related to this orogenic structure (Brunn *et al.* 1971); the following information is taken mainly from this publication.

The Western Taurids can be divided into two limbs which form an angle near Isparta, where they come together in the Pisidian Taurus. The western limb is formed by the Lycian Taurus, the eastern by the mountain range that was formerly called the "Taurus Occidental" (E of Antalya). The "Courbure d'Isparta" must have originated during the initial stages of Alpine orogenesis, and was accentuated by later formations of extensive *nappe* structures.

The Lycian *nappes* are an important group of *nappes*, and can be divided into a western part (in the neighbourhood of Köyçeğiz) and an eastern one. The eastern edge of the Lycian *nappes* extends from Elmali to Isparta. In the Lycian Taurus, *nappe* formation took place in two or even more stages. A second complex is formed by the Antalya *nappes*, stretching from Finike to Eğridir. Between the Lycian and Antalya *nappes* is situated the autochthonous chain of the Bey Dağlari, also with NE-SW strikes. A third group of *nappes* in the region are the Hoyran-Beyşehir *nappes*, extending as a narrow strip from Akseki in the SE to Hoyran in the NW. Between these *nappes* and the Antalya *nappes* another autochthonous mountain chain is present, which includes the Anamas Dağlari, with NW-SE strikes. The large plain of Antalya, with thick accumulations of Tertiairy and Quaternary sediments, is located between the two limbs of the "Courbure d'Isparta". The overthrusting took place mainly during Eocene and Miocene times.

The autochthonous rocks in the region consist chiefly of Mesozoic and Early Tertiairy limestone; they are taken together as the "Comprehensive Series". The autochthonous series terminates in Eocene nummulitic flysch, which also took part in the overthrusting. Along the west flanks of the Bey Dağlari, the youngest autochthonous rocks are Lower Miocene marine sediments. The allochthonous rocks, which make up the *nappes*, also consist predominantly of limestone. In the western Lycian *nappes* ultrabasic rocks were involved in the last stage of the overthrusting.

The deviating NE-SW strikes in the Lycian Taurus are of importance for the precipitation in that area, since rain is carried by S and SW winds from the Mediterranean.

2.1.3. THE LAKES

In the interior of Anatolia, a large area, extending from Gediz to Kayseri, is without drainage to the sea. In the Lycian Taurus the border of it is in some places only 35 km away from the sea (Stephan 1929). This area with interior drainage contains many lakes, particularly in its southern part. Most of these lakes are rather shallow (Philippson, 1918). Both fresh-water and salt-water lakes are present. Beyşehir Lake, Eğridir Lake, Söğüt Lake, Avlan Lake and Kestel Lake are fresh-water lakes. Salt-water lakes are Eber Lake, Akşehir Lake, Aci Lake and Salda Lake. Burdur Lake (formerly called Buldur) contains brackish water (Philippson 1918).

Stephan (1929) assumes that the fresh-water lakes have subterranean drainage. He argues that near some of these lakes faults are present, and that some of them show fluctuating water levels. The latter phenomenon is also noted by Philippson (1918) for some lakes in the Lycian peninsula, which seem to dry out now and then. In this connection it is perhaps significant that, according to Philippson (1918), *dolines* (sink-holes) and *terra rossa* are present in the limestone mountains of Lycia, pointing to karst processes.

2.1.4. RIFT VALLEYS

The West Anatolian Mountains, W of the Western Taurus, are characterized by the presence of many rift valleys. These structures are presumed to be the result of post-Alpine epeirogenetic movements. The major rift valleys have an E-W direction, but there is also a less important set of N-S faults. The latter seem to intersect the E-W faults, and should consequently be of more recent origin (Ilhan 1971). As for the Western Taurus, in the Köyçeğiz region some small, approximately N-S orientated, rift valleys are found. In the Lycian peninsula, at least one N-S rift valley of somewhat greater dimensions is present, along the Koca River (Xanthos Valley). Further, several lakes in this region are possibly related to these structures. Eğridir Lake, for example, is connected with a small N-S orientated rift valley.

2.1.5. EROSION

As a result of severe tree cutting and grazing, very extensive areas are almost completely deforested, and therefore suffer from extreme soil erosion. Dissected landscapes and *badlands* are the result. W of Korkuteli a severely deforested area has somewhat surprisingly been called "Orman Erozyon" (Forest of Erosion). Landslides and other features of erosion are widespread. In the landscape the effect of the erosion on different rock types is sometimes very clear. Thus, flysch and other easily eroded sediments produce extremely dissected sceneries, while limestone presents more smooth forms (figs. 2 and 3).

2.2. *NEOGENE AND QUATERNARY SEDIMENTS*

2.2.1. NEOGENE SEDIMENTS

Neogene sediments are very common in this area. These layers can give a striking aspect to the landscape, due to the white colour. It is possible to distinguish between marine sediments and continental deposits. The marine layers are bound to the southern borders of Anatolia, while the continental Neogene covers the greater part of the interior plateaus (fig. 4). The Neogene sediments generally lie more or less horizontally, and unconformably upon older deposits. Philippson (1918) distinguishes 3 facies:

1. sands, sandstones, gravels, etc.
2. carbonates, marls
3. vulcanic products, like tuffs, etc.

These 3 facies can be represented in many sequences and variations.

The continental Neogene layers to the west of approximately Akşehir contain scattered plant remains and also lignite. In many places lignite is present in such amounts that exploitation is possible. Thus, Philippson (1918) mentions one place between Afyon and Çay, not far from Karamik, where lignite was mined near the surface.

Brunn *et al.* (1971) state that the Neogene layers in the Lycian Taurus are mainly of Pliocene and possibly also of early Pleistocene ages, and that they are overlain by a widespread limestone horizon. They also mention the presence of continental red beds containing bones.

According to Bremer (1971) the Eşen rift valley (Koca River) is filled with limnic sediments of Pliocene and later date. He also describes recent epeirogenetic movements in the Karian-Lycian region. It seems that uplifting of the region has taken place since Late Pliocene times, accompanied by step fracturing. Simultaneously the coastal area has subsided.

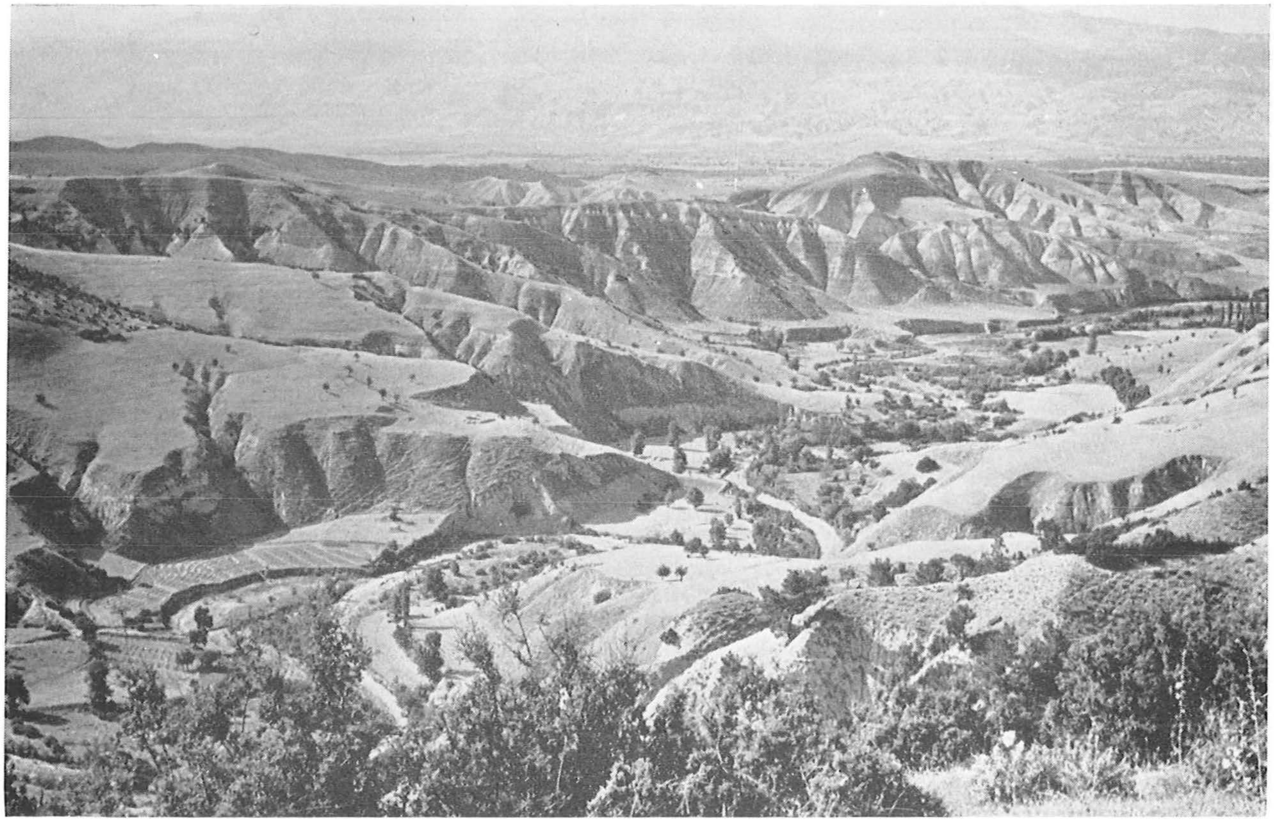
2.2.2. QUATERNARY SEDIMENTS

Not much can be found in the literature about Quaternary sediments in this region. Evidence of glaciations will be dealt with in 2.3.1. River terraces are mentioned by several authors, without, however, giving details. Terraces were also observed by the present authors, for example in the neighbourhood of Aydin, and W of Isparta. In some places at least 4 terraces could be tentatively traced.

Other Quaternary sediments in the area include rather extensive gravelbeds, situated especially alongside mountain chains. These gravelbeds occur chiefly in the transition zone between the Taurus and the interior plateau (Philippson 1918). They are often mixed with soil and do not show a clear stratification. These beds are sometimes affected by tectonic deformations, and mostly dissected by rivers. Their surface is generally rather flat, contrary to that of alluvial cones. Some authors explain their origin by postulating "pluvial" (*cf.* 2.3.3.) slope erosion.

Fig. 2. Landscape near Saraköy.

Fig. 3. Dissected landscape east of Sögüt Gölü (Orman Erozyon). To the right: limestone; to the left: flysch.



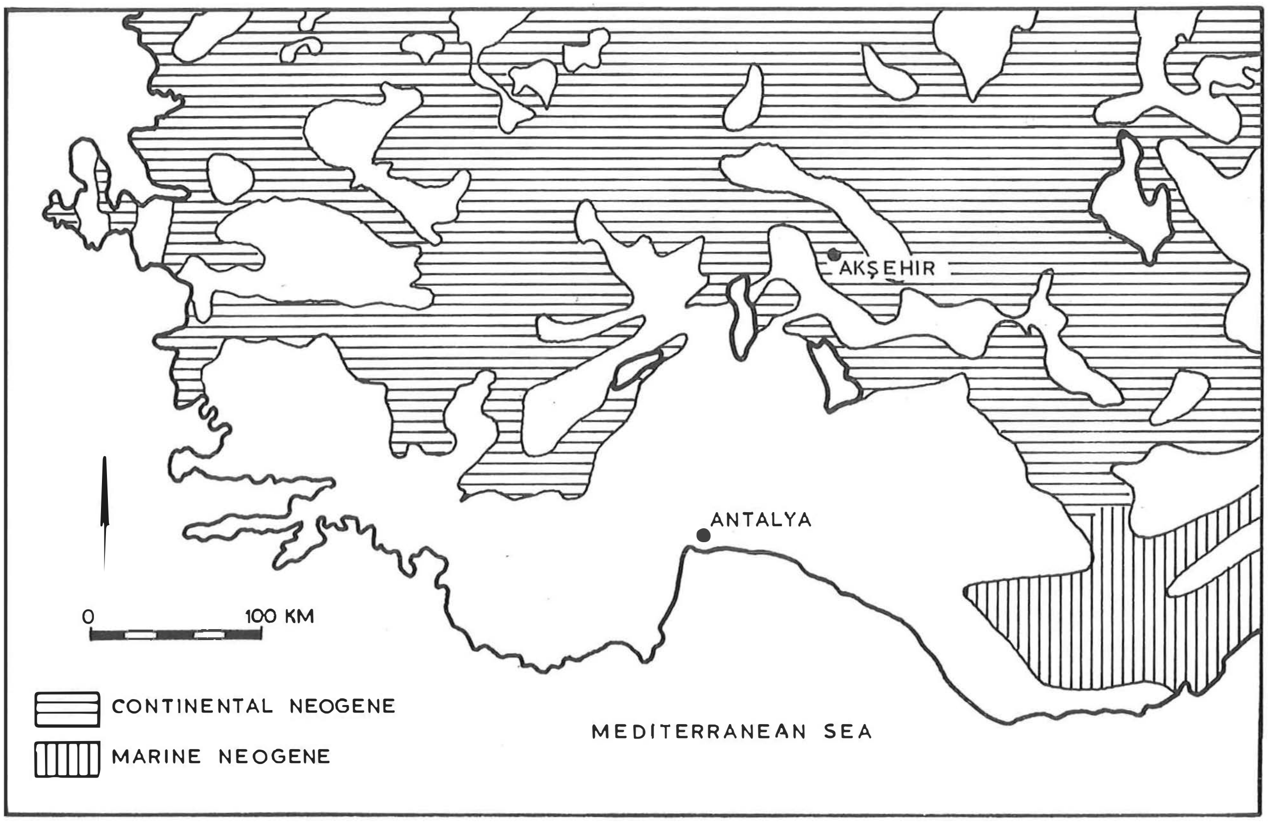


Fig. 4. Distribution of Neogene deposits in southwestern Turkey. After Brown & Jones 1971, fig. 2.

Further, alluvial cones and fans, deltas, slope *débris*, etc. occur. Philippson (1918) reports the probable occurrence of loess in the Lycian Taurus. Finally, the vast travertine beds in the Antalya basin should be mentioned here. Travertine is also present in smaller areas elsewhere, *e.g.* E of Denizli.

2.3. *OTHER GEOLOGICAL INFORMATION*

2.3.1. GLACIATIONS AND SNOWLINE DEPRESSIONS

Many articles have been written about snowline depressions during the last Glacial. It is of interest to summarize here some results of research in this field, because the pollen diagrams from the Near East provide evidence mainly of changes in precipitation, but hardly any of changes in temperature. An important publication on the subject, covering the whole of the Mediterranean area, is the one by Messerli (1967). The following information is taken from it.

In the Western Taurus, several mountains carried glaciers during the last Glacial: Sandras Dağ, Honaz Dağ, Ak Dağ, Bey Dağ, Davras Dağ, Barla Dağ, Bozburum Dağ and Dedogöl Dağ. The glacial snowlines vary between 2,300-2,400 m (?) (Sandras Dağ) to 2,650 m (Bey Dağ). The modern snowlines on these mountains are difficult to ascertain, since there are no glaciers at present. They can be roughly estimated by assuming that the difference in altitude between the modern snowline and the upper tree limit is about the same as on some mountains to the east, where this figure could be established: on Erçiyas Dağ and on Bolkardağ the difference is about 1,500 m. For two mountains in the Western Taurus the upper tree limit is known with some certainty: Ak Dağ – 2,000 m and Bey Dağ – 2,100 m. These figures suggest hypothetical modern snowlines at 3,500 and 3,600 m respectively. Comparison with their glacial snowlines, at 2,500-2,550 m and 2,650 m respectively, indicates a snowline depression of at least 1,000 m. The next (difficult) step is, to translate this figure into a decrease in temperature. Messerli is of the opinion that for the eastern Mediterranean area, a lapse rate of 0.65°C/100 m is a reasonable estimate. This would give a decrease in temperature of about 6-7°C during the coldest period of the last Glacial.

Messerli suggests that the first half of the last Glacial must have been relatively moist compared with the second half. Particularly in the later stages of the last Glacial an extremely asymmetrical glacier pattern, with hardly any ice on south-facing slopes, was probably present, suggesting rather dry conditions.

During the last Glacial, the snowline depression decreased from N to S and from W to E. In the western Mediterranean area the snowline depression would have been about 1,200-1,400 m, in the eastern area 1,000-1,200 m.

2.3.2. DEEP-SEA CORES

The study of Foraminifera and oxygen isotope analysis of deep-sea cores also provide information on palaeotemperatures, but not on changes in precipitation. The evidence obtained by Vergnaud-Grazzini and Herman-Rosenberg from a deep-sea core, taken W of Crete, points to an alternation of warmer and cooler periods (after Farrand 1971). In the lower part of the core (before 35,000 B.P.) the range of variation shown by the oxygen isotope analysis is about the same as that in modern planktonic fauna in the same region. After 35,000 B.P. the amount of O^{18} increases, indicating a decrease in temperature of 5-10°C between ca. 30,000 and 12,000 B.P.

2.3.3. INDICATIONS OF "PLUVIALS"

Pluvials in the strict sense are defined as periods with a higher precipitation than at present. Pluvials are also postulated for the Near East. Important are the presence of "pluvial lakes" (indications of former high water levels) and thick accumulations of slope deposits (*cf.* 2.2.2.). Pluvials are mostly correlated with glacial periods. It is still maintained that during the last Glacial, pluvial conditions prevailed in the eastern Mediterranean area (Farrand 1971).

It is evident that most of the basins in the Western Taurus formerly contained much larger lakes than at present. As an example is mentioned here the Konya basin (de Ridder 1965), where old shore lines, wave-cut cliffs, etc. prove the existence of a former huge lake. Human habitation in the Konya plain since at least 9,000 B.P. indicates that by that time the lake had already receded considerably. It is interesting that molluscs, recovered from the lake sediments, point to freshwater conditions. This implies that the former lake must have had a subterranean drainage. De Ridder mentions in this respect that the underlying limestone is affected by karst processes. The molluscs gave no clear indications of colder conditions in the past. Cohen & Erol (1969) report former high lake levels in the Burdur basin. They suggest that at the end of the Pleistocene a general recession took place in most of the lakes in the region. These recessions should have favoured the spread of human habitation, since relatively large areas of rich alluvial soil became available.

Palynological evidence indicates that, at least during the second part of the last Glacial, the climate was markedly drier than at present, so that there can have been no question of higher rainfall. However, there is no need to postulate a higher precipitation for an explanation of "pluvial lakes". The decrease in precipitation may have been more than compensated for by the reduction in evaporation.

Thick slope deposits can also be explained in another way. Rohdenburg (1970) points out that their accumulation must be due to a geomorphologically very active mechanism. He postulates rare but very heavy rain-showers. Such an extreme rainfall irregularity can produce truly "fluvial" landscapes, although the climate may be rather dry. According to Tricart (after Messerli 1967) such an irregular rainfall pattern is more characteristic of dry than of moist climates. Messerli (1967) also accepts this explanation for these badly sorted and heterogeneous thick slope deposits.

In summary it can be stated that a more favourable balance of precipitation and evaporation and an irregular rainfall distribution could explain several of the "pluvial" features.

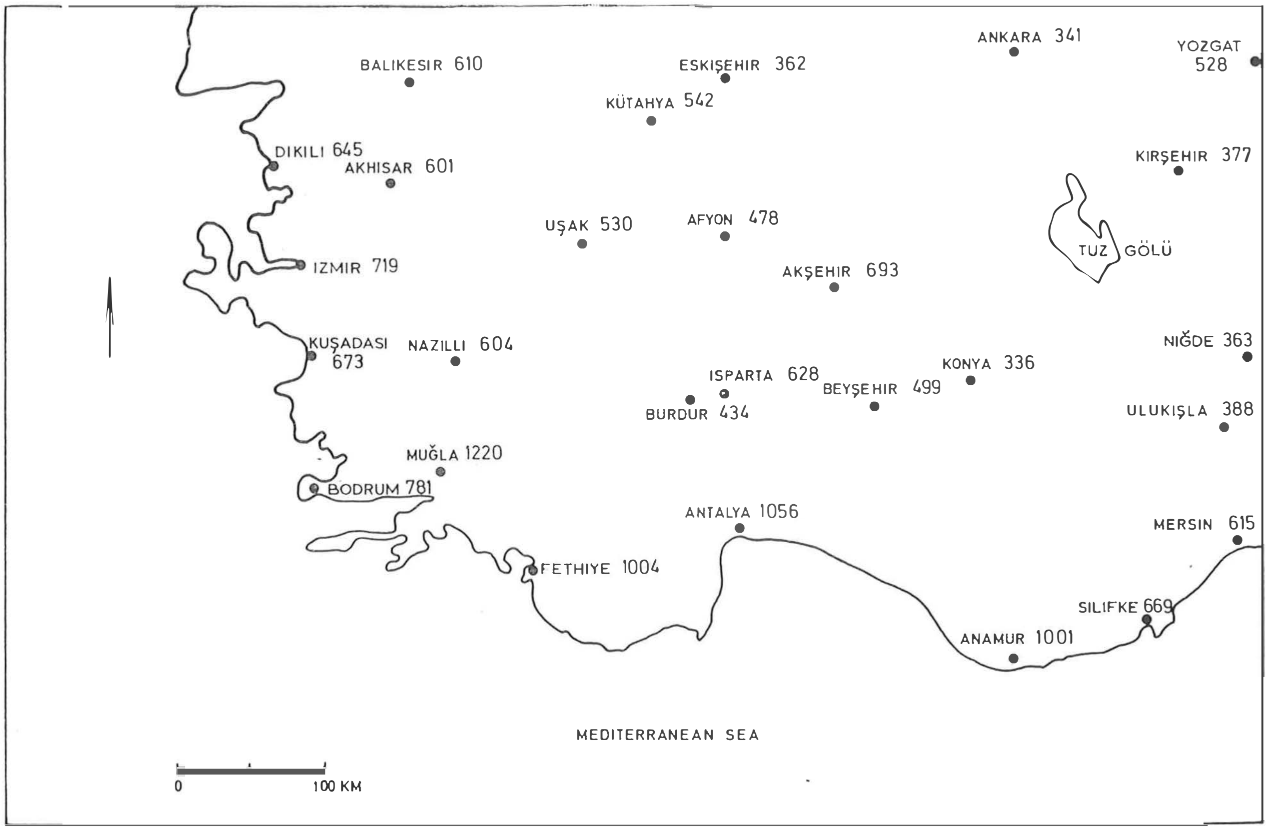


Fig. 5. Annual precipitation in southwestern Turkey. The number after the place-name is the precipitation in mm (after Walter 1955).

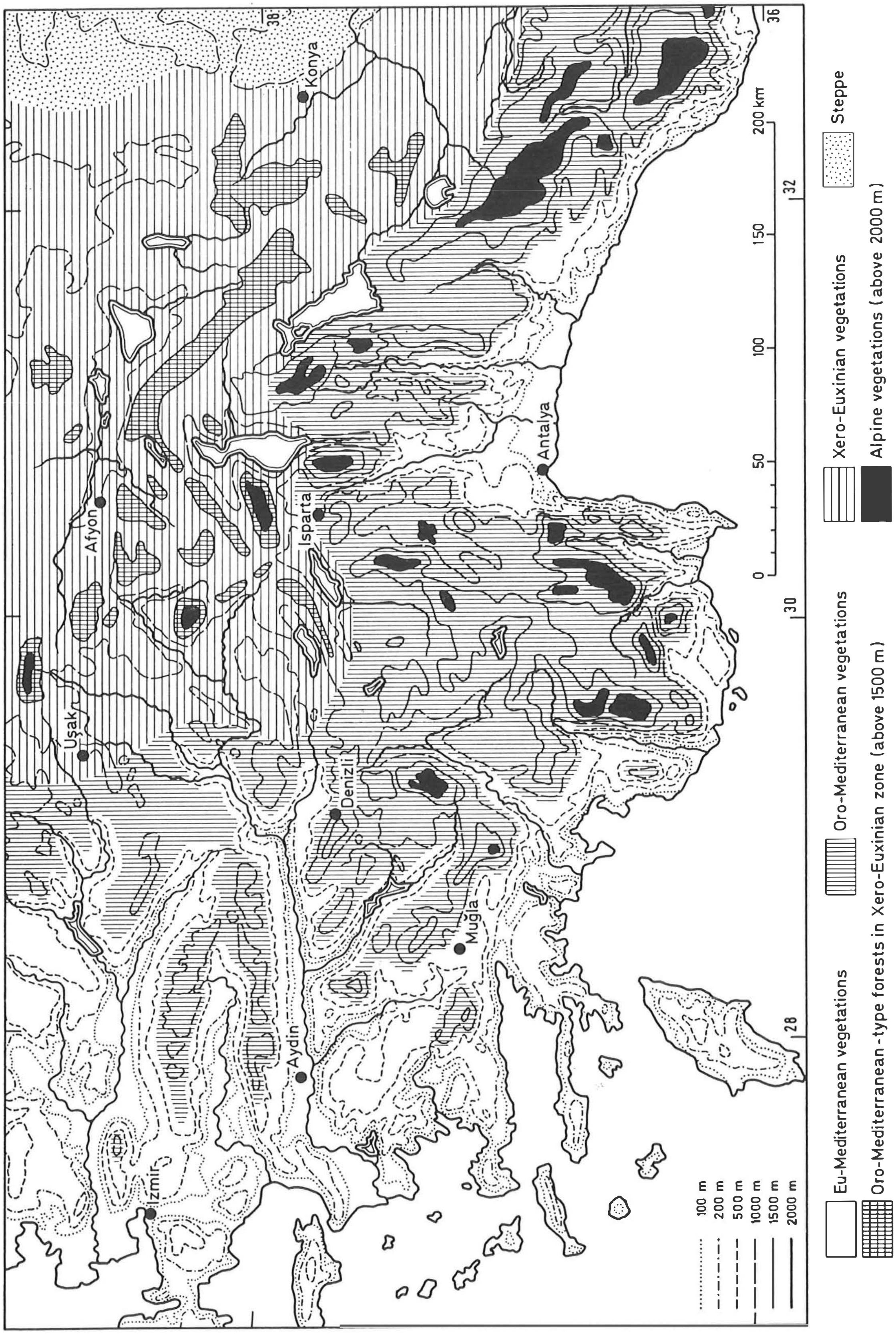
3. THE CLIMATE

Information on the climate of southwestern Turkey presented here is largely derived from Davis (1965, pp. 5-7), while the data on the precipitation (fig. 5) are after Walter (1955). Fairly detailed precipitation maps have been published for southwestern Turkey, among others by Lembke (1940). The greater detail of these maps is not based upon more information on the actual rainfall, but in reconstructing the distribution of the annual precipitation the topography has been taken into consideration.

The coastal area of southwestern Anatolia has a typical Mediterranean climate. Precipitation occurs in the autumn, winter and spring, from October to April, whereas the summers are nearly rainless. The weather stations on the south coast record average yearly precipitations of more than 1,000 mm, whereas on the west coast the rainfall hardly exceeds 700 mm. The winters are mild; temperatures rarely drop below freezing point. In spite of the hot summer with almost no rain, humidity is not particularly low as a result of the nearness of the sea. In broad west-east valleys, such as that of the Menderes river, Eu-Mediterranean climate and vegetation penetrate far into the interior of Anatolia.

Towards the interior the total amount of precipitation decreases, but a somewhat larger part of it falls in the summer. In the mountains, mean summer temperatures are not much lower than along the coast, but the winters are considerably colder. Areas above 1,000 m are usually snow-covered during the winter. It should be mentioned that in the whole of Southwest Turkey precipitation shows considerable annual fluctuations.

Fig. 6. Reconstruction of the distribution of the major vegetation units in southwestern Turkey (see chapter 4).


Konya
Afyon
Isparta
Uşak
Denizli
Antalya
Muğla
Aydin
Izmir
38
36
32
30
28
0
50
100
150
200 km
100 m
200 m
500 m
1000 m
1500 m
2000 m
Eu-Mediterranean vegetations
Oro-Mediterranean-type forests in Xero-Euxinian zone (above 1500 m)
Oro-Mediterranean vegetations
Xero-Euxinian vegetations
Alpine vegetations (above 2000 m)
Steppe

The climate of the Central-Anatolian Plateau has a more continental character. Mean annual precipitation is below 350 mm. Again, most of the precipitation occurs in the autumn, winter and spring. The winters are cold with average minimum temperatures below freezing point for several months. In spite of some rain the humidity is low during the summer. This is due to the high day temperatures and the often strong winds. That the average summer temperatures in the Central-Anatolian Plateau are lower than in the Mediterranean region is due to the sharp drop in temperature during the night. It will be clear that in Inner Anatolia the climate is much harsher and less favourable to plant growth than in the Mediterranean region.

4. THE PRESENT-DAY NATURAL VEGETATION ZONES

4.1. *INTRODUCTION*

One of the prerequisites for a satisfacory interpretation of pollen diagrams prepared from sediment cores is a general knowledge of the present-day vegetation in the area concerned. As for the whole of the Near East, the reconstruction of the natural vegetation in southwestern Turkey is seriously handicapped by the fact that man and his domestic animals, in particular the goat, have exercised their destructive influence on the vegetation for a long time. Moreover, data on the vegetation of southwestern Turkey are still scarce and scattered.

On the vegetation map of fig. 6 no vegetation types are shown, only a few conspicuous vegetation belts. For the construction of this map much use has been made of Zohary's (1973) book on the Geobotanical Foundations of the Middle East. Further, the studies of Louis (1939), Schwarz (1936), Walter (1956a), Markgraf (1958) and Quézel (1973) were consulted.

It should be emphasized that on the map of fig. 6 the delimitation of the vegetation belts is rather schematic and sometimes even arbitrary.

4.2. *EU-MEDITERRANEAN VEGETATIONS*

One of the vegetation belts distinguished on the map of fig. 6, is the so-called Eu-Mediterranean vegetation. The trees and shrubs of the Eu-Mediterranean vegetations consist mainly of evergreen species. This vegetation belt is found in the coastal area of southwestern Turkey, at elevations from sea-level to about 800 m. In broad river valleys, such as of the Menderes river, Eu-Mediterranean vegetations penetrate far into the interior of Anatolia. More inland the upper limit of the Eu-Mediterranean vegetations descends to 600-700 m.

In the lowest zone of the coastal area, up to elevations of 300 m, the Ceratonio-Pistacion lentisci is found. Of the characteristic and/or common arboreal species of the vegetations of the Ceratonio-Pistacion lentisci we can mention: *Pistacia lentiscus*, *Ceratonia siliqua*, *Olea europaea* var. *oleaster* (wild olive), *Quercus calliprinos*, *Spartium junceum*, *Calycotome villosa*, *Phillyrea media*, *Juniperus phoenicica* and *Erica verticillata.* In the Ceratonio-Pistacion lentisci vegetation zone *Pinus brutia* plays an important part, and pine forests with an undergrowth of Ceratonio-Pistacion lentisci species are quite common.

Vegetations of the Quercion calliprini are found above those of the Ceratonio-Pistacion lentisci, up to the upper limit of the Eu-Mediterranean vegetation belt. Above, it has been mentioned that the Ceratonio-Pistacion lentisci occurs up to 300 m, but that does not imply that Quercion calliprini vegetations would not be found below this altitude. Thus, Zohary (1973, p. 512) gives a sample record of a Quercion calliprini vegetation at an elevation of 50 m, near Izmir. In addition to *Quercus calliprinos*, which is mostly the dominant shrub in the Quercion calliprini vegetations, many other shrubs are found here, such as *Pistacia palaestina*, *Phillyrea media*, *Arbutus andrachne*, *Styrax officinalis*, *Quercus infectoria*, *Crataegus aronia*, *Fontanesia phillyreoides* and *Myrtus communis.* Also at elevations of between 300 and 800 m *Pinus brutia* forests play an important part. Vast stretches are covered by pine forest with an undergrowth of Quercion calliprini species. In particular *Quercus calliprinos* is a very common shrub in *Pinus brutia* forests.

There is a difference of opinion among plant ecologists on the original role of *Pinus brutia* in the Eu-Mediterranean vegetation belt. Schwarz (1936) is of the opinion that pine forest with an undergrowth of maquis species constitutes the climax vegetation in the larger part of the Eu-Mediterranean vegetation belt. Walter (1956a) and Zohary (1973, p. 525), on the other hand, claim that *Pinus brutia* would have invaded the territory of the Eu-Mediterranean maquis (Ceratonio-Pistacion lentisci and Quercion calliprini) after the destruction of the original plant cover by man. In this connection the results of the palynological study of the sediment core from Lake Köceğiz, at sea-level, are very instructive (7.6.).

Although the Quercion calliprini is named after *Quercus calliprinos*, this oak species is by no means confined to this syntaxonomic unit. It has already been mentioned that *Quercus calliprinos* forms part of Ceratonio-Pistacion lentisci vegetations, while this species can likewise be common in vegetations of the Oro-Mediterranean belt which will be discussed below. *Quercus calliprinos* is one of the hardiest Mediterranean species, which is found at elevations up to 1,700 m, where winter temperatures can be quite low. *Quercus calliprinos* has undoubtedly profited from the destructive activities of man. Kermes oak bushes are often the last remnants of former forest vegetations.

Mention should be made of the Quercetum macrolepidis anatolicum (Zohary 1973, p. 516), which vegetation unit is confined to western and southwestern Turkey. This forest type, which is characterized by *Quercus macrolepis*, may particularly be found near the inner (inland) border of the Eu-Mediterranean vegetation belt.

Of the trees and shrubs found along streams and in other wet places we can mention here: *Platanus orientalis, Salix* spec., *Ulmus campestris, Populus* spec., *Vitex agnus-castus* and *Alnus glutinosa. Liquidambar orientalis* deserves some special attention; it is a tree species which is confined to southwestern Anatolia. This tree can be common locally, among others in the Muğla district. Thus, the authors visited a marsh forest, about 6 km southwest of Karabörtlen, in which *Liquidambar*, *Fraxinus* and *Ulmus* formed the tree layer, with predominantly *Vitex* in the shrub layer (surface sample 8).

4.3. *ORO-MEDITERRANEAN VEGETATIONS*

Oro-Mediterranean vegetations extend from the upper limit of the Eu-Mediterranean vegetation belt to the upper forest line at elevations of about 2,000 m. In the lower part of the Oro-Mediterranean vegetation belt, between about 800 and 1,200 m, deciduous forests as well as coniferous forests occur. Up to an altitude of 1,000 m the coniferous forests are made up of *Pinus brutia*, whereas above that limit *Pinus nigra* prevails. However, on warm exposures *Pinus brutia* forests occur above 1,000 m, up to elevations of over 1,200 m. The dominant tree in the deciduous forests is *Quercus cerris. Quercus calliprinos* is frequently found in the shrub layer of *Pinus brutia* forests. *Quercus cerris* often forms a more or less dense undergrowth in *Pinus nigra* forests. As for the distribution of pine and oak forests in the lower zone of the Oro-Mediterranean belt, along the road from Akseki to Cevizli the authors observed large oak trees on level terrain with a deep soil, whereas the slopes were covered by *Pinus nigra* forest.

Towards the interior of Anatolia the pine and oak forests of the lower zone of the Oro-Mediterranean belt do not descend as far as 800 m, as on the western and southern slopes of the Taurus Mountains. Below elevations of 1,100 to 1,000 m the vegetations of the Oro-Mediterranean belt give way to those of the Xero-Euxinian steppe-forest belt which will be discussed below (4.5.).

In the upper forest zone, which generally extends from about 1,200 m to the upper timber line at about 2,000 m, coniferous forests are found. The main constituents of the montane forest vegetations are *Pinus nigra* (up to 1,800 m), *Cedrus libani*, *Abies cilicica* and *Juniperus excelsa.* These trees occur in nearly pure stands as well as in mixed forests. Virtually pure *Abies cilicica* forests occur north of Akseki, at elevations of 1,400 m and higher (fig. 7), while for the same area of the Western Taurus range, extensive *Cedrus-Abies* forests are reported by Zohary (1973, p. 561). At the southeastern side of Avlan Gülü, south of Elmali, a beautiful *Juniperus excelsa-Cedrus libani* forest (figs. 8 and 9) was observed by the authors (surface samples 38, 39 and 40). The shrub layer in this forest includes *Quercus calliprinos, Juni-*

perus oxycedrus, *Acer* aff. *monspessulanum*, *Lonicera* spec., *Berberis* spec., *Pistacia terebinthus/palaestina* and *Atraphaxis billardii*. As a degeneration stage of this *Cedrus-Juniperus* forest, a *Juniperus excelsa-Quercus calliprinos* shrub vegetation is found in the same area. The *Cedrus-Juniperus* forest near Avlan Gülü occurs as low as ca. 1,050 m. Zohary (1973, p. 158) mentions that north of Cevizli, about half-way from the coast to Beyşehir, *Cedrus* and *Abies* descend to about 1,000 m on northern exposures. These examples demonstrate, again, that the lower (and upper) limits of forest types vary considerably depending on soil, exposure, topography and other factors.

Fagus sylvatica is found on Murat Daği, ca. 40 km north-northeast of Uşak, at elevations of 1,600 to 1,700 m (Zohary 1973, p. 281).

Although *Betula* does not naturally occur in southwestern Turkey, some remarks on this tree will be made here because it is represented in the pollen diagrams which will be discussed in chapter 7. *Betula verrucosa* (= *B. pendula*), which is a rare species in Turkey, constitutes the highest forest zone in the mountains of northeastern Anatolia, up to elevations of ca. 2,400 m (Zohary 1973, p. 366; Rikli 1943, p. 662). *Betula* is also reported for the Erçiyas Dağ, south of Kayseri, in Central Anatolia. On the Erçiyas Dağ the upper forest zone is again made up by *Betula* which reaches an altitude of 2,500-2,600 m (Rikli 1943, p. 649).

Fig. 7. *Abies cilicica* forest, north of Akseki.

4.4. *ALPINE VEGETATIONS*

The alpine vegetations of southwestern Turkey were studied by Quézel (1973). Further, Schwarz (1936) describes alpine vegetations for Lydia, north of the Menderes river. The majority of the vegetations above the upper tree line consists of dry top-lawns (*pelouses écorchées*). The aspect of these vegetations is mostly determined by spiny, cushion-shaped species, such as *Astragalus angustifolius*, *Astragalus microcephalus*, *Acantholimon* *echinus* and *Onobrychis cornuta* (*Dornpolstersteppe*). However, unarmed species, in particular Labiatae, Scrophulariaceae, Caryophyllaceae, Boraginaceae and Gramineae, are generally predominant.

4.5. *THE XERO-EUXINIAN VEGETATION BELT*

North and east of the Oro-Mediterranean vegetation belt, in a region with lower average precipitation than in the Mediterranean zone and with increasing continentality towards the Central-Anatolian plateau, Zohary's Xero-Euxinian steppe-forest belt occurs. The designation "steppe-

Fig. 8. *Cedrus libani* near Avlan Gölü.

Fig. 9. *Juniperus oxycedrus* near Avlan Gölü.

forest" may give rise to confusion. The Xero-Euxinian steppe-forest region comprises, on the one hand, steppe vegetations with only scattered trees and, on the other hand, forest vegetations with a tree and shrub cover of 50% and more. For that reason the forests concerned are denoted here as Xero-Euxinian forests and the steppic vegetations with sparse tree growth as Xero-Euxinian forest-steppes.

The forests of the Xero-Euxinian vegetation belt consist largely of deciduous oak, of pine and of mixed pine and oak. The dominant tree in the pine forests is *Pinus nigra*, whereas *Quercus cerris* and *Quercus pubescens* are the main constituents of the deciduous oak forests. The oak forest is often reduced to brushwood as a result of cutting and grazing. Oak brush underwood is often found in *Pinus nigra* forest. *Juniperus excelsa* and *Juniperus oxycedrus* are quite common; they occur in oak and pine forests as well as in independent stands. Moreover, Zohary (1973, p. 280) mentions *Juniperus foetidissima* stands at elevations of 1,100 and 1,150 m north of Eskişehir, outside the area covered by the map of fig. 6. The Xero-Euxinian oak and pine forests differ from those of the Oro-Mediterranean vegetation belt by their more open character and by the ground flora which consists mainly of steppe elements.

Of the original forest-steppe vegetation very little is left. Solitary trees indicate that it was an oak forest-steppe, in which in addition to deciduous oak, wild fruit trees, such as *Pyrus elaeagrifolia* and *Crataegus laciniata*, were found.

The Xero-Euxinian forest vegetations occur at higher elevations; in these, the pine forests are situated above the oak forests. It is not possible to draw a line between the forest and forest-steppe areas. Too much has been destroyed of the original vegetation and, moreover, the transition from forest to forest-steppe must have been very gradual. Towards the Central-Anatolian Plateau remnants of forest stands are not found below 1,100 m, whereas more to the west the lower limit of the Xero-Euxinian forest may be below 1,000 m.

The demarcation line between Oro-Mediterranean and Xero-Euxinian oak and pine forests, as indicated on the map of fig. 6, is arbitrary. Because of the large-scale destruction of the original plant cover, this transition cannot be drawn more accurately. According to Zohary (1973, p. 579) the upper limit of the Xero-Euxinian forest would be at about 2,000 m. On the vegetation map of fig. 6 a hypothetical Oro-Mediterranean-type forest is indicated for elevations above 1,500 m in the Xero-Euxinian vegetation belt. This is done because the palynological evidence obtained for sediment cores from Karamik Batakliği and Hoyran Gölü (7.2. and 7.4.) suggests that under natural conditions Oro-Mediterranean-type forests should occur in the Xero-Euxinian zone.

4.6. *THE CENTRAL-ANATOLIAN STEPPE*

The timberless steppe vegetations of Central Anatolia belong to the class of the Artemisietea fragrantis anatolica (Zohary 1973, p. 482). The dominant species of these steppe vegetations is *Artemisia fragans.* Other species include *Astragalus* spp., *Centaurea* spp., *Eryngium* spp., *Thymus squarrosus*, *Salvia cryptantha*, *Teucrium polium*, *Phlomis armeniaca*, *Plumbago europaea*, *Verbascum pycnocephalus*, *Euphorbia macroclada*, *Bromus tomentellus* and *Stipa lagascae*.

Walter (1956b) is of the opinion that the present-day composition of the steppe vegetations in Central Anatolia is of secondary nature as a result of heavy grazing. In primary steppe vegetations, grasses, in particular *Bromus* and *Stipa* species, played a dominant part instead of *Artemisia*. This assumption is supported by the observation that grasses become dominant in areas which are protected against grazing. According to Zohary (1973, p. 392) "some parts of the Anatolian steppe may have had a grass-steppe as their climax vegetation". However, the climax vegetation of the "very core of Central Anatolia" should be an *Artemisia* steppe.

5. METHODS

5.1. *THE CORING*

The sediments were cored with a Dachnowsky sampler with an inner diameter of 3.7 cm and a useful length of 25 cm. Because of the generally compact sediments the borings had to be carried out in one hole. Often a drive frame equipped with chain hoists was necessary to push the sampler through the sediment.

5.2. *PREPARATION OF SAMPLES*

The clay and gyttja samples were prepared according to the following procedure:

1. After dehydration in absolute alcohol the sample was transferred to a bromoform-alcohol mixture with a specific gravity of 2.0.
2. The heavy liquid with the sample was left in an ultrasonic generator (40 kc/sec) for ca. 5 minutes in order to disintegrate the clay matrix. During centrifuging, the organic material became separated from the mineral particles which precipitated on the bottom of the tube.
3. The heavy liquid containing the organic material was diluted with alcohol, after which the organic material could be precipitated by centrifuging.
4. In order to remove remnants of bromoform the residue was washed with alcohol.
5. Subsequently the residue was gently boiled in 40-50% hydrofluoric acid for 1-3 minutes to dissolve the mineral particles which had escaped gravity separation.
6. The HF treatment was followed by acetolysis.
7. After acetolysis the residue was washed with water, stained with safranin, and transferred to silicone oil.

Preceding the above treatment peat samples were boiled in a 10% KOH solution for ca. 5 minutes.

The surface samples, consisting of moss cushions, were prepared in the following way:

1. Boiling in a 10% KOH solution for ca. 5 minutes.
2. HF treatment.
3. Acetolysis.
4. After acetolysis the samples were stained with safranin and mounted in silicone oil.

6. THE SURFACE-SAMPLE STUDY

6.1. *INTRODUCTION*

It is a well-known fact that as a result of differential production, dispersal and preservation of pollen, the share of the various pollen types in samples from lake and peat sediments does not generally correspond with the share of the plant taxa concerned in the past vegetation. Knowledge of the relation between modern pollen precipitation and vegetation may provide clues for the interpretation of fossil pollen spectra in terms of former vegetations.

For the Eastern Mediterranean area surface-sample studies have been published for northern Greece (Bottema 1974), southeastern Turkey (Van Zeist *et al.* (1968) 1970) and western Iran (Wright *et al.* 1967). The vegetations included in the studies mentioned above differ considerably from those in southwestern Turkey. For that reason it was felt necessary to supplement the palynological examination of sediment cores from southwestern Turkey with a study of the modern pollen precipitation in this region.

Surface samples consisting of patches of moss were taken in more or less natural, semi-natural and seriously degraded vegetations. It should be stressed that various vegetation types may have been missed. Vegetations at a greater distance from passable roads were not visited.

Due to lack of time and to insufficient knowledge of the flora of southwestern Turkey, the study of the vegetation in the vicinity of the surface-sample sites had to remain confined to incomplete inventories of the plants present, supplemented by estimates of the share of some quantitatively important species in the plant cover. Particularly the data on the herbaceous plants are rather fragmentary. Only a minor proportion of the herbs could be identified to the genus, let alone the species.

The surface-sample spectra are arranged into five groups. The grouping is based upon the natural vegetation zones (*cf.* chapter 4) from which the samples originate, *viz.* the lower and upper Eu-Mediterranean zones (tables 1 and 2), the Oro-Mediterranean zone (tables 3 and 4), and the Xero-Euxinian zone (table 5). Within each of these groups a further subdivision is made.

In table 6, for a selected number of pollen types, mean percentages per sub-group are given. The mean percentage is calculated in the following way. For example, in table 2, sub-group *a*, *Juniperus* is represented in 7 of the 8 samples. The sum of the *Juniperus* percentages in each of the samples in which this species is represented amounts to 5.6%. For the calculation of the mean percentage this sum is divided by 7 (and not by 8), which results in a value of 0.8%. The second figure indicates the number of samples in which the pollen type concerned was found. For instance, 5/7 indicates that the species concerned is represented in 5 of the 7 samples of that particular sub-group.

6.2. *THE SURFACE-SAMPLE LOCALITIES*

In this section the most relevant data on the sites where surface samples were collected, such as location, altitude and vegetation, are presented. The location of the samples is also indicated in fig. 10. It has already been mentioned that the vegetation surveys of the sampling localities are incomplete. In the enumeration of the sites the information on the plant growth has been condensed further; only the type of vegetation and the quantitatively most important species are mentioned. The first number is the sample number, the second number the approximate elevation.

1. 40-60 m, ca. 3 km N of Kuşadasi, near the coast. Maquis with predominantly *Quercus calliprinos*, *Pistacia lentiscus*, *Cistus villosus* and *Arbutus unedo*. Furthermore, among others, *Spartium junceum*, *Phillyrea media*, *Olea europaea* and *Poterium spinosum*.

2. ca. 500 m, near Meryemana. Whole area covered by dense maquis with predominantly *Phillyrea media*, *Arbutus unedo*, *Quercus calliprinos*, *Quercus infectoria*, *Erica verticillata* and *Cistus villosus*.

3. ca. 400 m, ca. 4 km W of Aziziye. Open *Pinus brutia* forest. Dense shrub layer with much *Erica verticillata*. Besides, *Phillyrea media*, *Quercus infectoria* and others.

4. ca. 600 m, ca. 12 km N of Germencik. Open *Pinus brutia* forest remnant on slope. In shrub layer predominantly *Quercus calliprinos*. The whole area is under cultivation (olive, fig, grain fields) with scattered forest remnants.

5. Same locality as 4. Sample 4 was taken in the upper part of the slope, sample 5 at the foot.

6. ca. 150 m, ca. 6 km N of Incirliova. *Pinus brutia* forest remnant in cultivated area (olive yards, grain fields). In dense shrub layer much *Quercus calliprinos*; furthermore, among others, *Olea europaea* (wild or escaped from cultivation).

7. Same area as sample 6. Maquis near river valley with *Platanus*. *Quercus calliprinos* and *Pistacia palaestina* are common in maquis.

8. ca. 100 m, ca 5 km SW of Karabörtlen. Swamp forest in valley with *Fraxinus excelsior*, *Liquidambar orientalis* and *Ulmus* spec.

9. ca. 250 m, ca. 3 km SE of Karabörtlen. *Pinus brutia* forest. In shrub layer particularly *Phillyrea media*, *Quercus infectoria*, *Erica verticillata*, *Cistus villosus* and cf. *Genista*.

10. ca. 1,000 m, ca. 10.5 km N of Köyceğiz. *Pinus brutia* forest area. In open shrub layer *Quercus calliprinos*, *Styrax officinalis* and others. *Platanus* and *Alnus* along streamlet.

11. ca. 500 m, ca. 8 km N of Köyceğiz. *Pinus brutia* forest. Poorly developed shrub layer. *Platanus* along streamlet.

12. ca. 20 m, ca. 18 km SE of Köyceğiz. *Pinus brutia* forest remnant on ridge alongside Dalaman river. *Styrax officinalis* common in shrub layer. Very well-developed herb vegetation.

13. ca. 20 m, ca. 8 km SE of Köyceğiz. *Pinus brutia* forest on upland along cultivated plain. Shrub layer with predominantly *Quercus calliprinos*, *Styrax officinalis* and *Myrtus communis*. At some distance a small *Liquidambar orientalis* marsh forest with *Alnus glutinosa*.

14. Sea-level, ca. 4 km N of Dalyanköy. Rock outcrop in marshy area along Köyceğiz Gölü, ca. 400 m south-southeast of the Köyceğiz coring locality.

15. ca. 600 m, ca. 5 km NE of Ula. Open *Pinus brutia* forest. The shrub layer includes *Styrax officinalis*, *Quercus calliprinos*, *Phillyrea media* and *Acer monspessulanum*.

16. ca. 750 m, ca. 6 km S of Muğla. Heavily grazed maquis, up to 1 m high. Predominantly *Quercus calliprinos*.

17. ca. 550 m, ca. 10 km WNW of Muğla. At the edge of wholly cultivated plain. Locally much

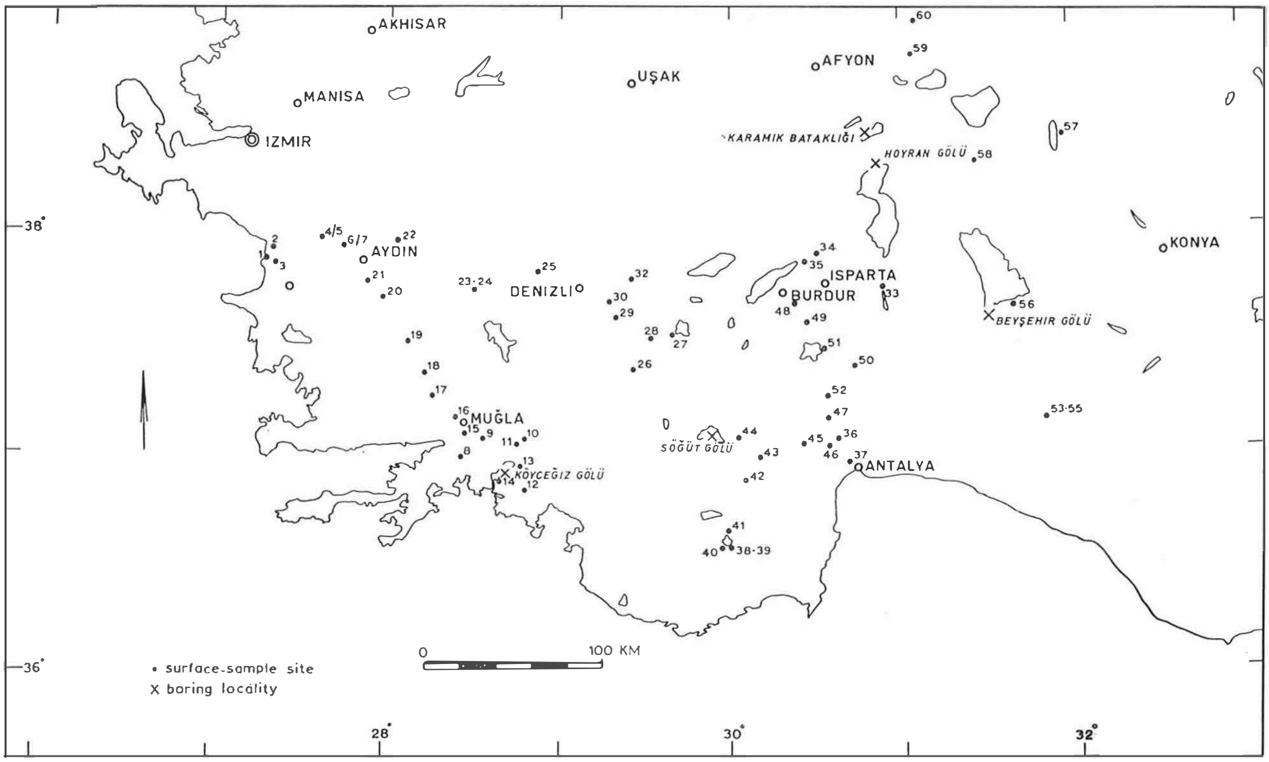


Fig. 10. Location of the surface-sample and pollen-diagram sites discussed in this paper.

grazing. Scattered shrub and some pine trees in the area.

18. ca. 650 m, ca. 4 km NE of Yatagan. Fairly dense maquis consisting largely of *Quercus calliprinos.*

19. ca. 350 m, ca. 45 km SSE of Aydin. Open, heavily grazed terrain. Some *Pinus brutia* in the area; furthermore, *Olea europaea, Phillyrea media*, *Quercus calliprinos*, *Quercus infectoria* and others.

20. ca. 130 m, ca. 25 km SSE of Aydin. At the edge of wholly cultivated plain. Heavily grazed terrain. Scattered *Quercus calliprinos* shrub.

21. ca. 100 m, ca. 10 km S of Aydin. At the edge of wholly cultivated plain. Heavily grazed terrain. No trees or shrubs.

22. ca. 400 m, ca. 10 km N of Kösk. Slopes covered by olive yards and scattered maquis. Some *Pinus brutia.* At short distance from sampling site fairly well-developed shrub vegetation including *Quercus infectoria*, *Quercus calliprinos* and *Pistacia palaestina.* In valley, where sample was taken, *Platanus*, *Juglans*, *Salix*, *Tamarix*, *Ulmus*, *Populus*, *Vitis*, *Hedera* and *Punica.*

23. ca. 1,250 m, ca. 7 km NNW of Karacasu. *Pinus nigra* forest remnant. In undergrowth *Pteridium aquilinum*, *Sanguisorba minor*, deciduous *Quercus* and others. *Hedera* in trees.

24. ca. 1,150 m, in same area as sample 23, distance between both samples ca. 2,000 m. Deforested terrain with dense vegetation of *Pteridium aquilinum.*

25. ca. 500 m, ca. 3 km N of Babadağ. Deforested area, scattered maquis and *Pinus brutia.* Grain fields and grazed terrain.

26. ca. 850 m, ca. 7 km SE of Acipayam. Cultivated plain. On slopes at the edge of the plain maquis and open terrain. *Salix* in the vicinity of sampling site.

27. ca. 1,250 m, near SW side of Salda Gölü. Grazed *Pinus nigra* forest. In shrub layer, up to 1 m high, *Cistus* spec., *Quercus* cf. *cerris* and *Juniperus oxycedrus.*

28. ca. 950 m, ca. 20 km ESE of Kizilhisar. Narrow part of east-west orientated valley. In valley grain fields, *Vitis* and fruit trees. On slopes maquis with fairly frequently *Quercus* cf. *infectoria.*

29. ca. 1,150 m, ca. 20 km SE of Denizli. Completely deforested and overgrazed terrain. Some small shrubs of *Prunus* and *Quercus calliprinos*. Grain fields at some distance.
30. ca. 1,150 m, ca. 15 km SE of Denizli. *Pinus nigra* forest. In shrub layer, up to 1 m high, *Juniperus oxycedrus*, *Quercus calliprinos* and *Cistus* spec.
32. ca. 710 m, ca. 4 km SE of Denizli. *Pinus brutia* forest. In shrub layer *Quercus calliprinos*, *Cotinus coggygria*, *Quercus infectoria*, *Crataegus* and *Pinus*. *Platanus* in valley with rivulet.
33. ca. 920 m, ca. 18 km S of Eğridir. In valley grain fields with well-developed deciduous oak trees. On grazed slope to the west of the valley scattered deciduous *Quercus*, *Pistacia palaestina*, *Juniperus oxycedrus* and *Quercus calliprinos*. *Styrax officinalis* is common in maquis. *Pinus* in upper part of the slope, 100-150 m above valley.
34. ca. 930 m, ca. 12 km NNW of Isparta. Cultivated plain: fields and fruit trees. On grazed slopes some shrub of *Quercus calliprinos* and *Crataegus*.
35. ca. 890 m, ca. 15 km NW of Isparta. At the edge of cultivated plain: grain fields, *Papaver*, some fruit trees. On slopes maquis and open terrain.
36. ca. 220 m, ca. 18 km NW of Antalya. Heavily grazed, open maquis with predominantly *Quercus calliprinos*. Besides, *Rhus coriaria*, *Pistacia palaestina*, *Vitex agnus-castus*, *Styrax officinalis* and *Phillyrea media*.
37. ca. 100 m, ca. 9 km NW of Antalya. *Pinus brutia forest*. In shrub layer predominantly *Ceratonia siliqua* and *Quercus calliprinos*. Furthermore, *Phillyrea media*, *Arbutus andrachne*, *Daphne angustifolia* and others.
38. ca. 1,050 m, ca. 20 km S of Elmali. Nearly undisturbed *Cedrus libani-Juniperus excelsa* forest on slope SE of Avlan Gölü. In open shrub layer, among others, *Juniperus* spp., *Acer* cf. *monspessulanum*, *Pistacia palaestina* and *Quercus calliprinos*. Sample from open place inside forest.
39. Same locality as sample 38. Sample from the foot of the slope.
40. ca. 1,050 m, ca. 22 km S of Elmali, about 3 km SW of the locality of samples 38 and 39. Cedar-juniper forest on slope southwest of Avlan Gölü. Sample from just outside the forest. *Quercus calliprinos* and *Acer monspessulanum* shrub at a short distance from sampling site.
41. ca. 1,100 m, ca. 15 km S of Elmali. Degradation stage after the cutting of the cedar-juniper forest. Maquis with predominantly *Juniperus excelsa* and *Quercus calliprinos*.
42. ca. 1,100 m, ca. 15 km NE of Elmali. Heavily grazed slope without trees and shrubs. For the greater part bare rocks. In a small valley at a short distance grain fields, *Populus*, *Salix*, *Vitis* and fruit trees.
43. ca. 1,130 m, ca. 30 km NE of Elmali. Scattered *Juniperus excelsa*, up to 5 m high. Maquis of nearly exclusively *Quercus calliprinos*.
44. ca. 1,350 m, ca. 4 km E of Kizilcadağ. Heavily grazed terrain with scattered *Juniperus excelsa*, up to 4 m high. Very open scrub vegetation with *Juniperus* spp., *Prunus* and *Berberis*. Much *Astragalus*. Grain fields.
45. ca. 600 m, ca. 25 km E of Korkuteli. *Pinus brutia forest*. Poorly developed shrub layer with predominantly *Quercus calliprinos*.
46. ca. 400 m, ca. 30 km E of Korkuteli. Dense maquis, up to 5 m high, with *Phillyrea media*, *Arbutus andrachne*, *Fontanesia phillyreoides*, *Pistacia palaestina*, *Olea europaea* and others. A few *Pinus brutia*.
47. ca. 350 m, ca. 30 km NNW of Antalya. Rather dense, grazed maquis with predominantly *Quercus calliprinos*, *Phillyrea media* and *Arbutus andrachne*.
48. ca. 1,050 m, ca. 10 km SE of Burdur. Deforested area. Grazed terrain and fields (cereal crop and opium poppy). In valleys *Populus*, *Morus*, *Salix*, *Juglans* and *Cannabis*. At some distance small group of pines.
49. ca. 1,150 m, ca. 18 km SE of Burdur. Same deforested area as sample 48. In flat parts grain fields; *Quercus calliprinos* scrub on grazed slopes. Rich herbaceous vegetation.
50. ca. 700 m, ca. 5 km N of Kocaaliler. Large *Pinus brutia* forest area. Scarce undergrowth with *Styrax officinalis*, *Fontanesia phillyreoides*, *Quercus calliprinos*, *Daphne sericea* and *Juniperus excelsa*.
51. ca. 700 m, ca. 5 km SW of Bucak. Grazed terrain with maquis and grain fields. Pine forest at 1,000 to 1,500 m.
52. ca. 700 m, ca. 22 km S of Bucak. Grazed slopes with maquis. Grain fields and fruit trees (*Juglans*)

on level terrain. Pine forest at 2 km or more from the sampling site. *Quercus calliprinos* is dominant in maquis.

53. ca. 1,400 m, ca. 4 km N of Akseki. Extensive *Abies cilicica* forest cover. Some *Juniperus oxycedrus*, *Juniperus excelsa* and *Crataegus* spec.

54. ca. 1,400 m, ca. 4 km N of Akseki. Same *Abies* forest as in sample 53. In the vicinity of the sampling site also *Ostrya carpinifolia*, *Pistacia* cf. *terebinthus*, *Quercus* cf. *cerris* and *Juniperus* observed.

55. ca. 1,500 m, ca. 6 km N of Akseki. In addition to *Abies cilicica*, some *Pinus nigra*. Furthermore, *Juniperus* and at some distance *Cedrus libani*. The sample was taken on an open spot with a fairly rich herbaceous vegetation.

56. ca. 1,150 m, ca. 18 km SW of Beyşehir, at the south side of Beyşehir Gölü. Rolling landscape. Grazed terrain as well as fields (grain, pulses). Scattered oak trees (*Quercus* cf. *pubescens*). Shrub of deciduous oak, *Juniperus oxycedrus*, *Berberis* and *Crataegus*.

57. ca. 1,030 m, ca. 17 km N of Ilgin, at east side of Çavuscu Gölü. Heavily grazed outcrop with predominantly *Artemisia* cf. *fragrans*, *Peganum harmala* and various Gramineae.

58. ca. 1,125 m, ca. 4 km SE of Akşehir. Dense shrub and low trees (up to 4 m high) on slope. Predominantly *Quercus* cf. *pubescens* and *Quercus calliprinos*. Besides, *Juniperus oxycedrus*, *Crataegus*, *Fraxinus* and others.

59. ca. 1,150 m, ca. 6 km N of Bolvadin. Plain east of Sultandağlari. Fields.

60. ca. 1,250 m, ca. 8 km SW of Emirdağ. Heavily grazed open *Juniperus excelsa* vegetation.

6.3. *THE LOWER EU-MEDITERRANEAN ZONE*

The surface samples from the lower Eu-Mediterranean vegetation belt are arranged in three sub-groups (table 1):

a. 5 samples from fairly well-developed *Pinus brutia* woods, although some of the forest remnants are of rather limited size and surrounded by fields, orchards and pasture land.

b. 3 samples from maquis with predominantly *Quercus calliprinos*.

c. 2 samples from areas largely devoid of wild trees and shrubs: fields and heavily grazed terrain.

The delimination of the sub-groups is not always clear. Thus, sample 36 of sub-group *b* constitutes, as it were, the transition to sub-group *c*. Similar problems were encountered in the grouping of the samples from the other vegetation zones. Sample 14 does not fit into any of the sub-groups distinguished.

The spectra of sub-group *a* are characterized by high *Pinus* pollen percentages, which may be expected for samples from pine forests. Of the shrubs from the undergrowth in the pine forests, *Phillyrea*, *Pistacia* and *Quercus* are represented in all samples. Particularly *Quercus calliprinos*-type pollen was counted in larger numbers. The conspicuously high *Quercus calliprinos* pollen value in sample 6 (22.2%) is the reflection of the dense shrub vegetation with predominantly kermes oak in the pine forest concerned. Although deciduous oak (*Quercus infectoria*) occurs only as scrub, its pollen is found regularly, indicating that even in a shrubby stage this species attains flowering.

As for the *Phillyrea/Fontanesia* pollen type, it was not until a late stage of the investigation had been reached that *Fontanesia* pollen was recognized. During the analysis of surface sample 46 (table 2), which is from a locality for which *Fontanesia phillyreoides* was recorded, *Fontanesia* pollen was distinguished from that of *Phillyrea*. In general most of the *Phillyrea/Fontanesia* pollen in the surface samples must have originated from *Phillyrea media*, which species is found at altitudes from 50 to 1,000 m (Zohary 1973, p. 397). *Fontanesia phillyreoides* extends from sea-level to 1,200 m, *i.e.* to the top of the *Pinus brutia* belt (pers. communication Professor Davis).

Pollen of the other shrubs in the undergrowth of pine forests, such as *Spartium*, *Genista* and *Styrax officinalis*, was only occasionally met with. Although *Styrax* was a common shrub in the vicinity of the locality of samples 12 and 13, its pollen was not counted in the samples concerned. On the other hand, *Olea* is well represented in the pollen precipitation. It is true that olives are widely cultivated in the lower and upper Eu-Mediterranean vegetation belts, but only in the vegetation of the site where sample 6 was taken, *Olea* (wild or escaped from cultivation) was observed. Not only the pollen spectra from the lower Eu-Mediter-

Table 1. Surface-sample spectra from the Lower Eu-Mediterranean zone.

	sub-group a					sub-group b			sub-group c		
Sample numbers	37	13	12	9	6	7	1	36	20	21	14
Σ AP	97.5	89.7	85.4	81.2	87.0	81.1	66.7	61.6	51.3	26.5	48.2
Abies	-	-	-	-	-	-	-	0.1	-	-	-
Alnus	-	4.2	0.3	0.7	0.1	1.5	0.2	0.1	0.1	0.2	0.9
Betula	-	-	-	-	-	-	0.1	0.1	-	-	-
Carpinus betulus	-	-	-	0.1	-	-	0.1	0.1	-	-	-
Castanea	-	-	-	-	-	-	-	0.1	0.2	0.1	-
Casuarina	0.1	-	-	-	-	-	-	-	-	-	-
Cedrus	-	-	-	-	-	-	-	0.1	-	-	-
Ceratonia	0.4	-	-	-	-	-	-	-	-	-	-
Citrus	-	-	-	-	-	-	-	-	0.1	-	-
Cornus	-	-	-	-	-	-	-	0.1	-	-	-
Corylus	-	-	-	0.1	-	0.1	-	-	-	0.1	-
Crataegus-type	0.1	-	-	-	0.1	-	0.1	0.1	-	-	-
Daphne	0.2	-	-	0.1	-	-	-	-	-	-	0.1
cf. Elaeagnus	0.2	-	-	-	-	-	-	-	-	-	-
Eucalyptus	-	-	-	-	-	0.1	-	-	-	0.6	-
Fagus	-	-	-	-	-	-	-	-	-	0.1	-
Fraxinus excelsior-type	-	-	-	-	-	-	0.1	-	-	-	-
Fraxinus ornus	-	-	-	-	-	-	0.1	0.1	-	-	-
Genista-type	-	-	0.1	0.2	-	-	0.1	-	-	-	-
Hippophaë	-	-	-	0.1	-	-	-	-	-	-	-
Juglans	-	-	-	0.1	0.7	0.8	0.1	0.1	0.2	0.2	-
Juniperus	2.0	-	0.5	0.1	0.1	0.1	0.4	0.4	0.1	0.3	0.5
Juniperus sabina	-	-	-	-	-	-	-	0.1	-	-	-
Liquidambar	-	9.2	0.5	0.3	-	-	-	-	-	0.1	0.2
Olea	0.9	5.4	3.3	1.2	12.4	30.6	3.6	2.7	9.0	7.8	2.0
Ostrya/Carpinus orientalis	0.1	-	0.1	-	-	-	0.1	0.1	-	-	-
Paliurus	-	-	-	-	-	-	-	-	-	-	4.0
Phillyrea/Fontanesia	1.0	0.5	0.2	1.0	0.2	0.1	2.0	1.3	0.4	0.5	0.1
Pinus	88.7	62.0	74.9	73.9	48.9	11.0	30.7	20.7	12.9	8.2	35.4
Pistacia	0.8	0.5	0.4	0.2	0.2	1.6	8.1	0.7	0.4	0.4	0.3
Platanus	0.1	0.5	0.2	0.1	0.1	9.5	0.4	0.8	0.1	0.1	-
Punica	-	-	-	-	-	0.2	-	-	-	-	-
Quercus calliprinos-type	2.1	5.6	4.0	2.6	22.2	19.1	20.1	32.8	24.7	5.8	2.8
Quercus cerris/infectoria-type	0.7	1.6	1.1	0.5	1.7	4.0	0.9	0.8	2.6	0.7	0.6
Rhamnaceae indet.	-	-	-	0.1	-	0.2	-	-	-	-	-
Rhus	-	-	-	-	-	-	-	0.1	-	-	-
Salix	0.1	-	-	0.1	0.1	0.8	0.1	0.1	0.1	1.3	0.1
Sambucus	-	-	-	-	0.1	-	-	-	-	-	-
Spartium	-	0.1	-	-	0.2	-	-	-	0.1	-	-
Styrax	-	-	-	0.1	0.2	0.1	-	0.3	-	-	-
Tamarix	-	-	-	0.1	-	0.5	-	-	-	-	0.8
Tilia	-	-	-	-	-	-	0.1	-	-	-	-
Ulmus	-	0.1	-	-	-	0.5	0.1	-	0.3	0.2	-
Viburnum	-	-	-	-	-	0.2	-	-	-	-	-
Vitex	-	-	-	0.1	-	0.1	-	0.1	0.2	-	0.1
Vitis	0.1	0.1	-	0.1	-	0.3	-	-	-	-	0.1
Σ NAP	2.5	10.3	14.6	18.8	13.0	18.9	33.3	38.4	48.7	73.5	51.8
Alisma	-	-	-	0.1	-	-	-	-	-	-	-
Echium-type	-	-	0.1	-	-	-	-	-	0.2	0.1	-
Heliotropium-type	-	-	0.1	-	-	-	-	-	-	-	-
Butomus	-	-	-	-	0.1	-	-	-	-	-	-
Campanula-type	-	-	-	-	-	0.1	0.3	-	-	-	-
Jasione-type	-	-	-	-	0.1	-	-	-	-	0.1	-
Humulus/Cannabis	-	-	-	-	-	-	-	0.4	-	-	-
Caryophyllaceae indet.	0.1	0.1	-	0.1	-	0.3	-	0.2	0.1	0.1	0.1

Table 1. cont'd

	sub-group a					sub-group b			sub-group c		
Sample numbers	37	13	12	9	6	7	1	36	20	21	14
Spergula arvensis	-	-	-	-	0.1	-	-	-	-	-	-
Spergularia	-	-	-	-	-	-	-	0.1	-	-	-
Chenopodiaceae indet.	0.1	0.4	0.9	0.3	0.9	0.5	1.9	-	1.1	0.6	2.0
Noaea-type	-	-	0.1	0.1	-	-	-	-	0.1	-	0.1
Cistus	-	-	-	0.8	1.8	0.1	0.7	-	0.1	-	-
Helianthemum	-	-	-	-	0.2	-	2.7	-	-	-	-
Artemisia	0.4	0.1	0.4	0.3	0.6	0.3	0.3	0.1	0.2	0.2	0.2
Centaurea cyanus-type	-	0.1	-	-	-	-	-	-	-	-	-
Centaurea scabiosa-type	-	-	-	-	-	-	-	-	0.1	-	-
Centaurea solstitialis-type	-	-	0.2	0.1	0.2	0.4	0.1	0.1	0.3	0.2	0.9
Cirsium-type	-	-	-	-	-	-	-	0.1	-	-	-
Crupina	-	-	-	-	-	-	0.1	-	-	-	-
Filago-type	-	-	-	0.1	-	-	-	-	-	-	-
Jurinea-type	-	-	-	0.1	-	-	-	-	-	-	-
Liguliflorae indet.	0.3	0.3	0.6	0.1	0.7	1.2	6.6	9.2	1.5	5.7	1.5
Matricaria-type	0.1	0.1	0.4	0.1	-	1.6	0.4	1.2	1.0	1.8	0.4
Onopordon-type	-	-	-	-	-	-	-	-	-	-	0.1
Scorzonera-type	-	-	0.1	-	-	-	0.1	0.3	-	-	-
Senecio-type	-	0.1	-	0.1	-	0.2	0.1	-	0.1	-	0.1
Tubuliflorae indet.	-	0.3	0.2	0.2	0.2	0.3	0.9	-	0.4	0.6	0.4
Xanthium	-	-	-	-	-	0.1	0.1	0.1	-	0.2	0.1
cf. Crassulaceae	-	-	-	-	-	-	0.1	-	-	-	-
Brassica-type	0.1	0.2	-	0.8	0.6	0.3	0.2	0.5	1.9	0.9	0.5
Cynocrambe	-	-	-	-	-	-	0.1	-	-	-	0.8
Cyperaceae	0.2	0.2	0.2	0.3	0.2	4.0	1.0	0.4	0.3	0.6	2.0
Datisca	-	-	-	-	-	0.3	-	-	0.1	-	-
Tamus	-	-	-	-	-	-	-	-	-	-	0.1
Dipsacus-type	-	-	-	-	-	-	-	-	0.1	-	-
Knautia-type	0.1	0.1	-	-	-	-	0.1	-	-	-	-
Ephedra distachya-type	-	-	-	0.1	-	-	-	-	-	-	-
Ephedra fragilis-type	-	-	-	0.1	-	-	0.2	-	-	-	-
Ericaceae	0.1	0.2	0.1	12.5	-	0.1	0.9	0.1	0.1	0.1	0.2
Euphorbia	0.1	-	0.1	-	-	0.1	-	0.1	0.1	-	0.1
cf. Mercurialis	-	-	-	-	-	-	-	-	-	0.1	-
Geranium	-	-	0.1	-	-	-	-	-	0.2	-	0.1
Gramineae indet.	0.3	1.8	9.0	1.1	1.4	3.8	5.0	4.5	3.9	4.3	3.1
Cerealia-type	-	-	-	0.2	0.5	0.3	0.6	0.3	0.9	0.2	0.2
Zea mays	-	-	-	0.1	0.1	0.1	-	-	-	-	-
Hypericum perforatum-type	-	0.1	-	-	0.1	0.1	0.6	0.1	0.1	-	0.2
Crocus	-	-	-	-	-	-	0.4	-	-	-	-
Gladiolus	-	-	-	-	-	-	1.2	-	-	-	-
Labiatae indet.	-	-	-	0.1	-	-	-	-	-	-	-
Stachys-type	-	-	0.1	-	-	-	-	-	-	-	-
Thymus-type	0.1	-	0.2	0.1	-	-	-	-	-	-	-
Leguminosae indet.	-	0.8	0.2	0.2	1.6	0.7	3.1	0.1	0.1	0.1	19.8
Lotus-type	-	-	0.2	-	-	-	-	0.1	-	-	-
Trifolium-type	-	-	0.1	-	0.3	-	-	-	0.3	0.1	0.1
Liliaceae indet.	-	-	-	0.1	-	-	-	-	-	-	-
Asparagus-type	-	0.1	-	0.1	-	-	-	-	0.1	-	-
Asphodelus	-	-	-	-	-	-	-	-	-	0.4	0.1
Maianthemum-type	-	-	-	-	-	-	0.1	-	0.1	-	-
Scilla-type	-	-	-	-	-	-	0.1	-	-	-	-
Linum	-	-	-	-	-	-	0.1	-	-	-	-
Lythraceae	-	-	-	-	-	-	0.1	-	-	-	-
Malva	-	-	-	-	-	-	0.1	-	-	-	-
Nuphar	-	-	-	-	-	-	0.1	-	-	-	-
Papaver	-	-	-	-	-	-	-	0.1	-	0.1	-
Plantago indet.	-	-	-	-	-	0.1	-	-	-	-	-

Table 1. cont'd

	sub-group a					sub-group b			sub-group c		
Sample numbers	37	13	12	9	6	7	1	36	20	21	14
Plantago lanceolata-type	0.2	0.7	0.5	0.4	0.3	0.7	0.5	16.4	21.5	55.2	2.0
Plantago major-type	-	-	-	-	-	-	-	0.1	-	-	-
Plantago maritima-type	-	-	-	-	-	-	-	-	0.1	-	-
Limonium-type	-	-	-	-	-	-	0.1	-	-	-	0.1
Polygonum aviculare-type	-	-	0.1	-	0.2	-	-	-	-	-	-
Rumex acetosa-type	-	0.2	-	0.1	0.4	2.2	0.1	0.3	9.9	0.6	1.0
Primula	-	-	-	0.1	-	-	-	-	-	-	-
cf. Caltha	-	-	-	-	-	-	-	0.1	-	-	-
Ranunculus repens-type	-	-	-	0.1	-	-	0.1	-	0.1	0.4	0.1
Thalictrum	-	0.1	-	0.1	-	-	-	-	-	0.2	-
Sanguisorba minor-type	-	1.0	-	0.1	0.1	-	0.8	0.1	-	-	0.1
Sanguisorba officinalis	-	-	-	-	-	0.1	-	-		-	-
Galium-type	0.1	0.2	-	-	0.2	0.1	0.1	0.4	0.8	0.1	-
Digitalis-type	-	-	-	-	-	-	-	0.1	-	-	-
Melampyrum	-	-	-	-	-	-	-	-	0.1	-	-
Rhinanthus-type	-	-	-	-	-	-	-	-	0.1	-	0.1
Scrophularia-type	0.1	-	-	0.1	-	-	-	-	0.1	-	0.1
Sparganium-type	0.1	0.7	0.2	0.3	0.4	0.2	0.9	-	-	0.1	12.5
Umbelliferae indet.	0.1	0.8	0.2	0.1	0.6	0.2	2.1	-	0.2	0.1	0.3
Bunium-type	-	1.6	0.4	-	1.5	-	-	3.1	-	-	-
Ferula-type	-	-	-	-	-	-	0.1	0.1	0.1	-	-
Malabaila	-	-	0.1	-	-	0.1	-	-	-	0.1	-
Urtica dioica-type	-	-	-	-	-	0.1	-	-	-	0.2	-
Urtica pilulifera	-	-	-	-	-	-	-	-	0.1	-	0.7
Valerianella	-	-	-	-	-	-	-	-	-	-	0.1
Anthoceros laevis	-	-	-	-	-	-	-	-	-	0.1	-
Botrychium	-	-	-	0.1	0.1	-	0.5	-	0.3	-	-
Cheilanthes	-	-	-	-	-	-	0.1	-	-	-	-
Dryopteris	-	-	0.1	0.1	-	0.2	0.2	0.1	0.1	0.1	0.4
Isoëtes	-	-	-	-	-	-	0.1	-	2.1	0.2	-
Polypodium	-	-	-	-	-	-	0.1	-	0.1	-	1.6
Pteridium	-	0.1	-	-	0.1	0.4	0.4	0.1	0.2	-	-
Pteris-type	-	-	0.1	-	-	-	-	-	-	-	-
cf. Sphagnum	-	-	-	0.1	-	-	-	-	-	-	-
Pollen sum	1417	1251	1260	2932	1226	1224	2868	1496	1906	1646	2605

Table 2. Surface-sample spectra from the Upper Eu-Mediterranean zone.

	sub-group a							
Sample numbers	3	4	5	11	15	32	45	50
$\sum$ AP	83.5	84.3	86.5	90.1	59.0	91.6	97.1	96.3
Abies	-	-	-	-	-	-	-	0.1
Acer	-	-	-	-	0.1	-	-	-
Alnus	0.1	0.4	0.2	1.0	-	-	-	-
Arbutus	-	-	-	-	-	-	-	-
Betula	-	-	0.1	-		-	-	0.1
Carpinus betulus	-	-	-	-	-	-	-	-
Castanea	-	-	-	-	0.4	0.3	-	-
Casuarina	-	-	-	-	-	-	-	-
Cedrus	-	-	-	-	0.1	-	-	0.1
Ceratonia	-	-	-	-	0.1	-	-	-
Citrus	-	-	-	-	0.1	-	-	-
Cornus	-	-	-	-	-	-	-	-
Corylus	-	-	0.1	-	-	-	-	-
Cotinus	-	-	-	-	-	0.3	-	-
Crataegus-type	-	-	-	-	-	0.1	-	-
Daphne	-	-	-	-	0.1	-	0.1	0.1
Eucalyptus	-	-	-	0.1	0.1	-	-	0.1
Fraxinus excelsior-type	-	-	-	-	-	0.3	-	0.1
Fraxinus ornus	-	-	-	-	-	0.3	-	-
Genista-type	-	-	-	0.1	-	-	-	-
Hedera	-	-	-	-	-	-	-	-
Juglans	0.2	0.1	-	0.1	0.4	0.3	-	-
Juniperus	0.4	1.0	0.2	0.2	0.2	0.6	-	3.0
Liquidambar	-	-	-	0.1	0.1	-	-	-
cf. Loranthus	-	-	-	-	0.1	-	-	-
Morus	-	-	-	-	0.5	-	-	-
Myrtus	-	-	-	-	-	-	-	-
Olea	7.3	13.3	13.4	2.0	1.1	1.9	1.4	0.8
Ostrya/Carpinus orientalis	-	-	0.1	-	0.1	-	-	0.1
Paliurus	-	-	-	-	-	-	-	-
Phyllyrea/Fontanesia	0.6	1.3	0.2	0.1	5.8	0.1	2.1	1.5
Pinus	69.8	46.5	54.2	81.7	25.7	76.4	84.7	86.1
Pistacia	1.0	0.9	1.9	0.6	5.0	0.1	0.5	0.6
Platanus	-	-	0.5	1.5	0.2	1.4	0.1	0.1
Populus	-	-	-	-	-	-	-	-
Prunus-type	-	-	-	-	-	-	-	-
Quercus calliprinos-type	2.6	16.2	15.4	2.0	16.6	2.6	3.6	2.0
Quercus cerris/infectoria-type	1.1	4.1	1.8	0.2	1.9	6.6	0.5	1.3

sub-group b					sub-group c					
2	16	18	46	47	17	19	22	25	51	52
58.5	61.0	87.8	93.7	88.0	72.9	81.1	55.9	30.1	65.5	85.2
-	-	-	-	-	-	-	-	-	0.6	0.3
-	-	-	-	-	-	-	-		-	-
0.2	0.1	0.2	0.1	0.2	-	0.1	0.1	0.1	0.2	0.6
0.7	-	0.1		0.3	-	0.1	-	-	-	-
-	-	-	-		-	-	-	-	-	-
	-	0.1	-	-	-		-	-	-	-
-	0.1			-	-	-	-	0.1	-	0.1
-	0.1	-	-		-	-	-	-	-	-
-	-	0.1	-	0.2	-	-	-	-	-	0.7
-	-	-	-	0.4	-	-	-	-	0.1	0.1
-	-	-	-	-	-	-	-	-	0.6	-
-	-	-	-	0.2	-		-	-	-	-
0.1	0.1	0.1	-	0.1	-	-	-	-	-	
-	-	-	-	-	-	-	-	-	-	-
-	-	0.2	-	-	-	-	-	0.1	0.2	0.5
-	0.3	-	-	1.3	-	-	-	-	-	0.1
-	-	0.1	-	-	-	0.1	-	-	-	-
-	-	-	-	-	-	-	-	-	-	0.1
-	-	-	3.9	-	0.1	-	-	-	0.3	-
0.1	-	0.1	-	-	0.1	0.1	-	-	-	-
-	-	-	-	-	-	-	-	0.1	-	-
0.2	0.2	0.1	-	0.1	0.1	-	11.8	0.1	0.2	6.4
0.5	1.6	0.2	3.5	5.9	0.1	-	0.5	0.1	6.5	5.6
-	0.1	0.1	-	-	-	0.7	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	0.2	-
-	-	-	0.1	-	-	-	-	-	0.1	-
5.2	5.0	5.2	21.0	4.7	5.9	5.6	20.2	0.5	1.0	0.8
-	-	0.1	0.2	0.1	-	-	-	-	0.6	0.4
	0.1	-	0.5	-	-	-	-	-	0.1	-
17.5	1.4	0.2	19.4	19.4	0.2	1.4	0.3	0.1	2.2	2.6
12.9	26.2	39.0	22.8	27.6	49.3	26.3	3.2	25.3	42.2	47.3
1.4	0.7	-	0.8	7.1	0.7	0.3	1.7	0.1	1.2	2.0
0.1	0.2	0.1	-	0.2	1.0	0.2	10.6	0.3	0.2	0.1
-	-	-	-	-	0.1	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	0.2
11.1	22.7	40.4	20.5	18.2	12.6	44.0	4.4	2.3	4.9	13.9
8.0	1.9	1.3	0.7	1.6	2.1	2.1	1.9	0.7	3.3	3.4

Table 2. cont'd

	sub-group a							
Sample numbers	3	4	5	11	15	32	45	50
Rhamnus	-	-	-	0.1	-	0.1	-	-
Rhus	-	-	-	0.1	-	-	-	-
Salix	-	-	-	-	0.1	0.1	-	0.1
Sambucus	-	-	-	-	-	-	-	-
Spartium	-	0.3	0.2	-	-	-	-	-
Styrax	-	-	0.1	-	0.5	-	-	0.1
Tamarix	0.4	-	-	-	-	-	-	-
Taxus	-	-	-	-	0.1	-	-	-
Tilia	-	-	0.1	-	-	-	-	-
Ulmus	-	0.1	0.1	0.1	-	0.1	-	-
Vitex	-	-	-	-	-	-	-	-
Vitis	-	0.1	0.1	-	-	-	-	-
$\sum$ NAP	16.5	15.7	13.5	9.9	41.0	8.4	2.9	3.7
Alisma	-	-	-	-	-	-	-	-
Calla	-	-	-	-	-	-	-	-
Anchusa-type	0.1	-	-	-	-	-	-	-
Echium-type	-	-	0.2	-	-	-	-	-
Heliotropium-type	-	-	-	-	0.1	-	-	-
Butomus	-	0.1	-	-	-	0.1	-	-
Campanula-type	-	-	0.1	-	0.1	-	-	-
Jasione-type	0.2	-	-	-	-	-	-	-
Humulus/Cannabis	-	-	-	-	-	0.3	-	-
Caryophyllaceae indet.	0.3	0.3	0.1	0.2	-	0.1	-	-
Spergula arvensis	-	-	-	-	0.1	-	-	-
Spergularia	-	-	-	-	0.1	-	-	-
Centaurium	0.1	-	-	-	-	-	-	-
Chenopodiaceae indet.	1.1	1.4	0.5	0.1	0.1	0.8	0.3	0.3
Aellenia-type	-	-	-	0.1	-	-	-	-
Noaea-type	-	-	-	-	-	-	-	-
Cistus	0.5	-	0.5	0.2	1.8	-	-	-
Helianthemum	0.3	0.1	0.1	-	0.1	-	-	-
Artemisia	0.2	0.7	0.3	0.1	0.1	1.3	0.2	0.4
Carthamus-type	-	-	-	-	-	-	-	-
Centaurea cyanus-type	-	-	-	-	0.1	-	0.1	-
Centaurea scabiosa-type	-	-	-	-	-	-	-	-
Centaurea solstitialis-type	0.2	0.3	-	0.1	0.2	0.1	-	-
Cirsium-type	-	-	-	-	0.1	-	0.1	0.1
Cousinia	-	-	-	-	-	-	-	-
Filago-type	-	-	-	-	0.1	-	-	-

sub-group b					sub-group c					
2	16	18	46	47	17	19	22	25	51	52
-	0.2	-	-	0.1	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	0.2	-
0.2	0.1	-	-	-	-	0.2	0.3	-	-	-
-	-	0.1	-	-	0.1	-	-	-	-	-
0.2	-	0.1	-	-	-	-	-	-	-	-
-	-	0.1	-	-	0.1	-	-	-	0.1	-
0.2	-	-	-	-	-	-	0.8	-	-	-
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
0.1	0.1	0.2	-	-	0.2	0.1	0.1	0.1	-	-
-	-	-	0.1	-	-	-	-	-	-	-
-	-	-	-	0.1	0.1	-	0.1	-	0.1	-
41.5	39.0	12.2	6.3	12.0	27.1	18.9	44.1	69.9	34.5	14.8
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	0.1	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
0.1	-	-	-	0.1	-	-	-	0.6	-	0.3
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	0.1	-	-	-	-	-
-	0.1	-	-	-	-	0.3	-	-	-	-
6.0	-	0.3	-	-	-	-	0.1	-	-	0.1
-	-	0.1	0.1	0.1	-	-	-	-	0.4	-
0.1	0.2	0.1	-	0.8	0.1	0.5	0.1	0.2	1.3	0.1
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	0.1	-	-
-	-	-	-	-	-	-	-	-	-	-
0.5	0.4	0.6	0.1	0.4	0.8	0.2	0.2	1.1	0.6	0.6
-	-	-	-	-	-	-	-	-	-	-
0.1	0.1	-	-	0.1	-	-	-	-	-	-
0.1	-	0.1	-	-	-	1.9	-	0.2	-	-
2.4	0.1	-	-	-	-	-	-	-	0.2	-
0.6	0.5	0.1	0.2	-	0.2	-	0.1	0.7	1.3	1.0
-	-	-	-	-	-	-	0.1	-	-	-
-	-	-	-	-	-	0.1	-	-	0.1	-
-	-	-	-	0.2	-	-	-	-	-	-
0.6	0.2	-	-	-	0.1	0.1	-	0.1	0.6	0.1
-	-	0.1	-	0.1	0.7	-	-	0.1	0.2	-
-	-	-	-	0.1	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-

Table 2 cont'd

	sub-group a							
Sample numbers	3	4	5	11	15	32	45	50
Gundelia-type	-	-	-	-	-	-	-	-
Jurinea-type	-	0.1	0.1	-	-	-	-	-
Liguliflorae indet.	1.7	0.9	0.5	1.8	2.5	0.1	-	0.1
Matricaria-type	0.1	0.4	0.4	-	2.8	0.3	-	0.1
Scorzonera-type	-	-	-	-	-	-	-	-
Senecio-type	-	-	-	-	0.4	-	-	-
Tubuliflorae indet.	0.4	0.4	0.2	0.2	0.1	0.1	-	-
Xanthium	-	-	0.2	-	0.2	0.1	-	-
Convolvulus	-	-	-	-	-	-	-	-
Crassulaceae	-	-	-	-	0.1	-	-	-
Brassica-type	0.2	0.4	0.2	-	0.2	0.5	0.6	0.3
Capsella-type	-	-	-	-	-	-	-	0.1
Cynocrambe	-	-	-	-	-	-	-	-
Cyperaceae	0.2	1.1	0.4	0.2	0.8	0.5	-	-
Datisca	-	-	-	-	-	-	-	-
Dipsacus-type	-	-	-	-	-	-	-	-
Knautia-type	-	-	0.1	-	-	-	-	-
Ephedra fragilis-type	-	0.1	-	-	0.1	-	-	0.1
Ericaceae	5.2	0.9	0.1	0.2	14.0	0.3	-	-
Euphorbia	-	0.1	0.1	-	-	-	-	-
Mercurialis	-	-	-	-	-	-	-	-
Erodium	-	-	-	-	-	-	-	-
Geranium	-	-	0.1	-	0.2	-	-	-
Gramineae indet.	2.8	2.8	3.6	1.5	1.2	1.5	0.6	0.9
Cerealia-type	-	0.1	0.8	-	-	0.1	0.1	-
Secale	-	-	-	-	-	-	0.1	-
Zea mays	-	-	-	-	0.1	-	-	-
Hypericum assyrianum-type	-	-	-	-	-	-	-	-
Hypericum perforatum-type	0.2	0.4	0.3	-	0.5	-	-	-
Gladiolus	-	-	-	-	-	-	-	-
Stachys-type	-	-	-	-	-	0.1	-	-
Thymus-type	-	-	-	0.2	0.1	-	-	-
Leguminosae indet.	0.3	2.3	0.9	0.5	1.3	0.1	0.1	-
Lotus-type	-	-	-	-	0.2	-	-	-
Trifolium-type	0.2	0.1	0.1	1.1	2.4	0.1	0.1	-
Vicia-type	-	-	-	-	1.3	-	-	-
Liliaceae indet.	-	-	-	-	0.2	-	-	-
Allium	-	-	-	-	-	-	-	-
Asparagus-type	-	0.1	-	-	-	-	-	-

sub-group b					sub-group c					
2	16	18	46	47	17	19	22	25	51	52
-	-	-	-	-	-	-	-	0.1	-	-
-	-	-	-	-	-	-	-	-	-	-
1.3	6.4	0.9	0.4	0.6	7.2	0.3	0.7	12.0	10.0	0.3
0.4	1.5	0.5	0.1	0.6	0.4	0.9	0.6	1.6	1.4	0.2
-	0.1	-	-	-	-	-	-	-	-	-
0.1	0.1	-	0.1	-	0.1	-	-	-	0.1	0.1
0.4	0.7	-	0.1	0.3	0.4	-	-	0.4	0.8	-
-	0.2	-	-	-	-	0.1	-	0.1	-	0.1
-	-	-	-	-	0.1	-	-	-	-	-
-	-	-	-	-	-	-	-	-	1.0	-
0.1	1.3	0.9	1.8	0.8	0.4	3.8	0.1	4.6	2.1	1.1
-	0.1	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	0.1
0.9	0.6	0.2	-	0.2	1.0	0.1	0.1	7.3	-	-
-	-	-	-	-	-	-	-	-	0.2	-
-	-	-	-	-	-	-	-	-	-	-
-	0.1	-	-	-	-	-	-	-	-	-
0.1	0.1	-	-	-	-	-	-	-	-	0.1
10.6	0.2	0.1	-	-	0.3	-	-	-	-	0.1
-	-	0.1	-	0.2	0.1	-	-	-	-	0.1
-	-	-	-	-	-	-	0.1	-	-	-
0.1	-	-	-	-	-	-	-	-	-	-
0.1	-	-	-	-	-	-	-	0.4	-	-
11.6	15.6	3.5	1.7	2.7	6.3	2.1	35.7	4.1	6.9	3.4
0.1	1.0	0.2	-	0.5	1.4	0.4	0.1	0.5	1.8	1.9
-	-	-	-	-	-	-	-	-	0.2	0.1
-	-	-	-	-	-	-	0.1	-	-	-
-	-	-	-	-	-	0.1	-	-	-	-
0.9	-	-	-	-	0.1	-	-	-	0.1	-
0.1	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
-	-	0.1	-	-	0.1	0.7	0.1	0.1	-	-
1.2	-	0.3	0.3	0.1	0.8	1.0	0.7	0.1	-	0.1
-	0.3	-	-	0.1	-	-	-	-	-	-
0.2	-	-	0.5	0.7	0.1	1.8	0.5	-	0.2	0.1
-	-	-	-	-	-	1.8	0.1	-	-	-
0.1	-	-	-	-	-	-	-	-	-	-
-	0.1	-	-	-	-	-	-	-	-	-
0.2	-	-	-	-	0.2	-	0.1	0.1	-	-

Table 2. cont'd

	sub-group a							
Sample numbers	3	4	5	11	15	32	45	50
Asphodelus	-	-	0.1	-	0.1	-	-	-
Maianthemum-type	-	-	-	-	-	-	-	-
Scilla-type	-	-	-	-	0.1	-	-	-
Lippia	-	-	-	-	0.1	-	-	-
Lythrum	-	0.1	-	-	-	-	-	-
Menyanthes	-	-	-	-	-	-	-	-
Nymphaea	0.1	-	-	0.1	-	-	-	-
Papaver	-	-	-	-	-	-	-	0.1
Plantago indet.	-	-	-	-	-	-	-	-
Plantago lanceolata-type	0.4	0.6	0.7	0.2	0.6	0.8	0.2	0.4
Plantago major-type	-	-	-	-	-	-	-	-
Plantago media-type	-	-	-	0.1	-	-	-	-
Limonium-type	-	-	-	-	-	-	-	-
Polygonum aviculare	0.1	-	-	-	0.1	-	-	-
Rumex acetosa-type	0.3	0.4	1.1	-	0.1	0.3	0.1	0.1
Cyclamen	-	-	-	-	-	-	-	-
Anemone-type	-	0.1	0.1	-	1.2	-	-	-
cf. Caltha	-	-	-	0.1	-	-	-	-
Nigella	-	-	-	-	-	0.1	-	-
Ranunculus indet.	-	-	-	-	-	-	-	-
Ranunculus arvensis	-	-	-	-	-	-	-	-
Ranunculus asiaticus	-	-	-	-	0.1	-	-	-
Ranunculus repens-type	0.1	-	-	-	3.5	0.1	-	-
Thalictrum	-	0.3	-	-	0.1	-	-	-
Rosaceae indet.	-	-	-	-	-	-	-	-
Filipendula	-	-	-	-	-	-	-	-
Sanguisorba minor-type	0.4	-	0.3	-	1.9	-	0.2	0.1
Galium-type	-	-	0.1	0.5	0.3	-	0.1	0.1
Saxifraga hirculus-type	-	-	-	-	-	-	-	-
Anthirrhinum-type	-	-	-	-	-	-	-	-
Melampyrum	-	-	-	-	-	-	-	-
Rhinanthus-type	-	-	0.1	-	-	-	-	-
Scrophularia-type	-	-	-	-	0.4	-	-	-
Solanum dulcamara	-	-	-	-	0.1	-	-	-
Sparganium-type	0.1	0.3	0.1	0.6	0.2	0.3	0.1	-
Umbelliferae indet.	0.5	-	0.2	0.3	0.3	0.1	-	0.1
Anisosciadium	-	-	-	-	-	-	-	-
Bunium-type	0.1	-	-	0.1	0.6	-	-	0.1

sub-group b					sub-group c					
2	16	18	46	47	17	19	22	25	51	52
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	0.1	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	0.1	-	-	-
-	-	-	-	-	-	-	0.3	-	-	-
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	0.1	-	-	0.1
-	-	-	-	-	-	-	-	0.5	-	-
0.7	2.8	2.6	0.4	0.6	1.2	0.5	0.2	31.5	2.3	1.4
-	-	-	-	-	-	-	-	-	0.1	-
-	-	-	-	-	-	-	-	-	0.1	-
-	-	-	-	0.1	-	-	-	-	-	-
-	-	-	-	0.2	-	-	-	-	0.2	-
0.5	0.2	0.6	-	-	0.2	1.1	2.5	0.2	-	0.2
0.1	-	-	-	-	-	-	0.1	-	-	-
-	-	-	-	-	-	0.1	-	-	-	-
-	-	-	-	-	0.1	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	0.1	-	-	-
-	-	-	-	-	-	-	-	-	-	0.1
-	-	-	-	-	-	-	-	-	-	-
0.1	0.1	-	0.1	0.1	-	-	0.4	-	0.1	0.2
-	0.1	-	-	-	-	0.1	-	-	0.2	0.1
-	-	-	-	-	0.1	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
0.3	0.1	-	-	-	0.1	0.1	0.1	-	-	0.1
0.2	1.2	0.2	0.3	0.1	1.5	-	0.1	0.1	0.2	0.2
-	-	-	-	-	-	-	-	-	0.2	-
-	-	-	-	-	-	-	-	0.4	-	-
-	-	-	-	-	-	0.1	-	-	-	-
-	-	-	-	-	-	-	-	-	0.2	0.1
-	-	-	0.1	-	-	-	-	-	0.2	-
-	-	-	-	-	-	-	-	-	-	-
0.4	0.2	0.2	-	0.3	-	0.2	0.3	0.1	0.2	0.1
0.8	3.5	0.3	0.1	0.7	1.8	0.5	0.1	1.0	0.4	1.1
-	-	-	0.1	-	-	-	-	-	-	0.4
-	0.8	0.1	-	0.8	0.2	-	-	0.2	0.5	0.1

Table 2. cont'd

	sub-group a							
Sample numbers	3	4	5	11	15	32	45	50
Ferula-type	-	-	-	-	-	-	-	-
Malabaila	-	-	-	-	-	-	-	0.1
Urtica dioica-type	-	-	-	-	-	-	-	-
Botrychium	0.1	-	-	-	-	-	-	-
Cheilanthes	-	-	-	-	-	-	-	-
Dryopteris	-	0.1	-	-	0.1	-	-	-
Ophioglossum	-	-	-	-	-	-	-	-
Pteridium	0.2	0.1	1.6	0.1	-	0.3	-	0.2
Pteris-type	-	-	-	1.2	-	-	-	-
Pollen sum	1248	709	1342	896	1714	800	1548	1387

sub-group b					sub-group c					
2	16	18	46	47	17	19	22	25	51	52
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	1.0	-	-
-	-	-	-	0.1	0.1	0.1	0.5	-	0.1	-
-	-	0.1	-	-	-	-	-	-	-	-
-	0.1	-	-	-	-	-	-	-	-	0.1
0.1	0.3	0.1	-	0.1	0.1	0.1	-	0.1	0.1	0.6
-	-	-	-	-	-	-	-	0.1	-	-
0.1	0.1	0.2	0.1	-	0.2	0.3	0.1	0.5	-	0.1
-	-	-	-	-	-	-	-	-	-	-
2315	1144	1247	1073	982	927	1148	1572	1472	1255	1397

Table 3. Surface-sample spectra from the Oro-Mediterranean pine forest area.

	sub-group a				sub-group c									
Sample numbers	10	27	30	23	28	29	26	48	49	35	34	33	44	24
Σ AP	93.1	78.0	89.9	87.7	73.3	62.8	60.4	63.9	56.6	59.4	49.9	71.6	82.7	58.8
Abies	-	-	-	-	-	-	-	-	0.1	0.1	0.1	-	-	-
Acer	-	-	-	-	-	-	-	-	-	-	-	0.2	-	-
Alnus	3.9	0.1	-	-	0.1	0.7	-	0.1	-	0.1	-	-	-	0.1
Arceuthobium	-	-	-	-	-	-	-	-	-	-	-	-	2.6	-
Betula	-	0.1	-	-	-	-	-	-	-	0.1	-	-	-	-
Carpinus betulus	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
Castanea	-	0.3	0.1	0.3	-	-	-	-	-	0.1	-	0.3	-	0.3
Cedrus	-	-	-	0.1	0.6	0.1	-	0.1	0.4	0.1	-	-	0.2	-
Ceratonia	-	-	-	-	-	-	-	0.1	0.1	-	-	-	-	-
Citrus	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-
Cornus	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-
Corylus	0.1	-	-	-	0.1	0.1	-	0.1	-	-	0.1	0.1	-	0.1
Cotoneaster	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-
Crataegus-type	-	-	0.6	0.1	-	0.9	0.3	0.1	0.1	0.6	0.4	1.8	-	0.1
Daphne	-	-	-	-	-	-	-	0.1	-	-	0.1	-	-	-
Fagus	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-
Fraxinus excelsior-type	-	-	-	-	-	0.1	-	0.2	-	0.1	0.1	0.2	-	-
Fraxinus ornus	-	-	-	-	-	0.4	-	0.1	-	0.1	0.1	0.2	-	-
Genista-type	0.2	-	-	-	-	-	-	-	0.3	-	-	-	-	-
Hedera	-	-	-	0.2	-	-	-	-	-	-	-	-	-	0.1
Jasminum	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
Juglans	-	0.1	0.3	0.1	-	0.6	0.3	0.8	0.3	1.0	0.6	0.1	-	0.1
Juniperus	0.2	5.2	2.2	0.5	1.7	1.9	0.3	9.1	7.2	0.8	2.9	13.3	34.1	0.3
Liquidambar	0.2	-	-	-	-	0.1	0.3	-	-	-	-	-	-	-
Morus	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-
Olea	1.3	0.1	0.6	1.1	0.8	1.3	0.3	1.6	1.1	0.4	0.2	0.6	0.5	2.1
Ostrya/Carpinus orientalis	-	-	-	0.1	-	0.1	-	0.3	0.1	0.2	0.2	0.7	0.1	-
Paliurus	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-
Phillyrea/Fontanesia	0.2	-	-	-	-	0.4	-	2.7	1.5	0.4	0.2	1.3	0.1	-
Picea	-	-	-	-	-	-	-	0.1	0.1	-	-	-	-	-
Pinus	80.5	58.8	82.3	81.9	56.4	36.3	48.2	34.3	33.1	42.5	37.6	33.1	42.1	47.7
Pistacia	0.3	-	-	-	0.4	0.2	0.6	1.0	0.9	0.2	0.6	0.7	0.1	0.2
Platanus	2.4	0.4	0.3	-	0.3	0.3	-	0.9	0.5	0.2	-	1.9	0.1	0.2
Prunus-type	-	-	-	-	0.3	0.1	-	-	0.1	-	-	-	-	-
Populus	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-
Quercus calliprinos-type	3.6	0.7	1.7	2.4	5.2	16.1	4.0	7.8	8.0	3.8	3.5	7.2	1.9	6.1
Quercus cerris/infectoria-type	0.2	11.4	1.7	0.9	4.1	2.0	1.7	3.5	1.8	1.6	2.4	9.6	0.8	1.4
Rhamnus	-	-	-	-	0.1	0.4	-	-	-	-	-	-	-	-
Rhus	-	-	-	-	-	-	-	-	-	0.2	-	-	-	-
Rubus-type	-	-	-	0.1	-	-	-	-	-	-	-	-	-	0.1
Salix	-	-	0.1	-	2.5	0.2	4.6	0.7	0.1	6.1	0.2	0.1	-	-
Spartium	-	-	-	-	-	-	-	-	0.1	-	-	-	-	-
Styrax	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-
Tamarix	-	-	-	-	0.1	0.1	-	0.1	-	-	-	-	-	-
Taxus	-	-	-	-	-	-	-	0.1	-	-	-	-	-	-
Tilia	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-
Ulmus	-	-	-	-	0.1	0.2	-	0.2	0.2	-	-	0.1	-	0.2
Viscum	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-
Vitex	-	-	-	-	-	-	-	-	0.1	-	-	-	-	-
Vitis	-	0.4	-	-	0.1	0.1	-	-	0.1	-	0.1	-	-	-
Σ NAP	6.9	22.0	10.1	12.3	26.7	37.2	39.6	36.1	43.4	40.6	50.1	28.4	17.3	41.2
Calla	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-
Cynoglossum-type	-	0.1	-	-	-	-	-	-	-	0.1	0.4	-	-	-
Echium-type	-	-	-	-	-	-	-	-	-	-	0.5	0.1	-	-
Symphytum-type	-	-	-	-	-	-	-	0.3	0.1	-	0.1	-	-	-
Humulus/Cannabis	-	0.1	-	0.7	-	0.1	0.3	3.7	0.5	5.4	-	-	-	-

Table 3. cont'd

	sub-group a				sub-group c									
Sample numbers	10	27	30	23	28	29	26	48	49	35	34	33	44	24
Campanulaceae indet.	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-
Jasione-type	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-
Caryophyllaceae indet.	-	0.1	0.1	-	-	-	0.9	0.1	1.3	0.1	0.9	0.1	0.3	0.1
Spergularia	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-
Chenopodiaceae indet.	0.3	1.0	0.4	-	0.7	0.9	0.9	1.4	0.8	2.5	1.0	1.7	0.3	0.6
Noaea-type	0.2	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Cistus	-	0.3	0.3	0.1	0.1	-	-	-	-	-	-	0.3	0.1	1.4
Helianthemum	-	-	-	-	-	-	-	-	-	-	-	-	1.4	-
Artemisia	-	2.5	1.3	0.3	1.0	2.3	0.6	4.5	2.9	1.9	2.6	1.4	0.4	0.2
Centaurea cyanus-type	-	-	-	0.1	-	-	-	0.2	-	0.1	-	-	0.3	0.2
Centaurea scabiosa-type	-	-	-	-	-	0.1	-	-	-	-	0.5	-	-	-
Centaurea solstitialis-type	0.7	0.4	0.3	0.1	0.7	1.2	7.7	0.3	0.3	0.5	0.6	0.1	0.3	0.2
Cirsium-type	-	-	0.1	-	0.7	-	0.6	0.3	0.1	0.1	0.6	-	0.4	-
Cousinia	-	-	-	-	-	-	-	0.1	-	-	-	-	-	-
Gundelia-type	-	-	-		-	-	0.6	-	-	-	-	-	-	-
Liguliflorae indet.	1.3	0.1	1.8	0.1	0.4	4.1	0.6	0.5	4.0	2.4	2.5	4.2	0.3	1.3
Matricaria-type	0.2	0.3	0.3	0.2	0.4	1.1	2.0	1.7	3.9	1.8	3.2	4.3	0.3	1.5
Onopordon-type	-	-	-	-	-	-	-	0.1	-	-	-	-	-	-
Scorzonera-type	-	-	-	-	-	-	-	-	-	-	0.1	-	0.1	-
Senecio-type	-	-	-	0.1	-	0.1	-	-	0.5	-	0.1	-	-	0.1
Tubuliflorae indet.	0.2	0.3	0.4	-	0.1	0.4	0.3	0.1	0.3	0.4	0.5	0.8	-	-
Xanthium	-	-	-	-	-	0.2	-	0.1	-	0.4	0.7	0.1	-	0.1
Convolvulus	-	-	-	-	-	-	0.3	-	-	-	0.1	-	-	-
Crassulaceae	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-
Brassica-type	-	1.2	0.5	0.1	0.4	2.8	-	1.4	0.7	2.4	1.9	0.8	0.5	1.8
Capsella-type	-	-	-	-	-	-	-	0.1	-	0.2	0.1	0.4	-	-
Cyperaceae	0.3	2.8	0.3	-	0.1	0.1	0.9	0.7	0.2	1.2	1.5	0.7	-	-
Datisca	-	-	-	7.6	-	-	-	0.1	-	-	-	-	-	9.1
Knautia-type	-	-	-	-	-	0.1	-	-	-	-	0.1	-	-	-
Scabiosa palaestina-type	-	-	-	-	-	-	-	-	-	-	0.2	-	-	-
Ephedra distachya-type	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Ephedra fragilis-type	-	-	-	0.1	-	-	-	-	-	0.1	0.1	-	-	-
Ericaceae	-	-	-	-	-	-	-	-	-	0.2	-	-	-	-
Euphorbia	-	-	-	-	-	-	0.3	0.1	-	0.6	-	-	-	-
Mercurialis	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-
Geranium	-	-	-	-	-	-	-	-	0.1	-	-	-	-	-
Gramineae indet.	1.6	3.0	1.3	0.9	2.2	10.9	8.6	14.2	11.1	8.6	19.2	5.0	10.5	4.5
Cerealia-type	0.1	1.5	1.0	0.1	15.4	6.3	6.8	1.3	2.1	3.7	3.2	1.5	0.9	0.2
Secale	-	-	-	-	0.4	-	-	0.1	0.3	0.7	0.5	0.7	0.3	-
Zea mays	-	-	-	-	0.7	-	0.3	-	-	-	-	-	-	-
Myriophyllum	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-
Hypericum perforatum-type	0.1	-	-	0.1	0.1	-	-	-	-	-	-	0.1	-	0.1
Stachys-type	-	-	-	-	-	-	-	0.1	-	-	-	-	-	0.2
Thymus-type	0.1	-	-	-	-	-	-	-	0.1	-	-	-	-	-
Leguminosae indet.	-	0.3	0.4	-	-	0.4	0.1	0.2	0.3	0.1	0.4	0.3	0.1	0.1
Astragalus-type	-	-	-	-	-	-	-	0.1	0.1	-	-	-	-	-
Lotus-type	-	-	-	-	-	0.1	-	-	-	0.1	-	-	-	-
Onobrychis-type	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Trifolium-type	0.2	-	-	-	-	0.1	-	0.1	0.5	-	-	0.3	0.1	-
Vicia-type	-	-	-	-	-	-	0.6	-	0.1	-	-	-	-	-
Asparagus-type	-	-	-	-	-	-	-	-	-	0.1	-	0.7	-	-
Asphodeline	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
Colchicum	-	-	-	-	-	-	-	-	0.1	-	-	-	-	-
Fumaria	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
Papaver	-	-	-	-	-	0.1	1.7	0.1	0.1	0.5	0.4	0.4	-	-
Plantago laceolata-type	0.2	2.7	1.2	0.3	1.1	1.7	1.7	1.4	11.0	1.3	2.5	1.6	0.3	0.9
Plantago major-type	-	-	-	-	-	-	-	0.1	-	-	-	-	-	-

Table 3. cont'd

	sub-group a				sub-group c									
Sample numbers	10	27	30	23	28	29	26	48	49	35	34	33	44	24
Plantago maritima-type	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-
Limonium-type	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
Fagopyrum	-	-	-	-	-	-	0.3	-	-	-	-	-	-	-
Polygonum aviculare-type	-	-	0.1	-	-	0.3	0.3	0.1	0.2	-	0.1	0.2	-	0.1
Rumex acetosa-type	0.1	-	0.3	0.4	0.1	0.3	1.1	0.1	-	0.5	0.2	0.7	-	1.7
Anagallis-type	-	-	-	-	-	-	-	-	-	-	0.2	-	-	-
Anemone-type	-	-	-	-	-	-	-	-	0.1	-	-	-	-	-
Delphinium-type	-	-	-	-	-	0.1	-	0.1	-	-	0.1	0.2	-	-
Nigella	-	-	-	-	-	-	0.3	-	-	-	-	-	-	-
Ranunculus arvensis	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Ranunculus peltatus-type	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Ranunculus repens-type	-	0.4	-	0.1	-	0.4	0.9	-	-	0.1	-	-	-	-
Thalictrum	-	-	-	-	-	0.1	-	-	-	0.2	0.1	-	-	-
Rosaceae indet.	-	-	-	-	-	-	0.3	-	-	-	-	-	-	-
Filipendula	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
Geum-type	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-
Potentilla-type	-	-	-	-	0.3	0.1	-	-	-	-	-	-	-	-
Sanguisorba minor-type	0.4	0.4	0.1	-	-	0.1	-	0.8	0.1	-	0.1	-	-	-
Asperula-type	-	-	-	-	-	-	-	-	0.1	-	-	-	-	-
Galium-type	-	1.2	-	-	-	0.4	-	0.2	0.4	1.1	0.5	0.2	-	0.4
Rhinanthus-type	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-
Scrophularia-type	-	0.1	-	-	-	-	-	0.1	-	0.1	-	-	0.2	0.2
Solanum dulcamara	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-
Sparganium-type	0.1	0.1	0.1	-	0.3	0.3	0.3	0.1	0.1	0.7	-	0.6	0.1	-
Umbelliferae indet.	-	0.7	-	0.3	0.3	1.1	0.3	0.2	0.6	0.5	1.1	0.3	0.1	0.2
Anisosciadium	-	-	-	-	-	-	-	0.1	-	-	0.2	-	-	-
Bunium-type	-	-	-	-	-	0.4	-	-	0.3	0.1	0.6	-	0.2	1.1
Bupleurum-type	-	-	-	-	0.1	-	-	-	0.1	0.4	0.1	-	-	-
Eryngium-type	-	-	-	-	-	0.1	-	0.1	-	-	0.7	-	-	-
Ferula-type	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-
Malabaila	-	-	-	-	-	-	-	0.1	-	-	0.1	0.1	-	-
Pimpinella-type	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-
Urtica dioica-type	-	-	-	-	-	0.1	-	-	-	0.2	-	-	-	-
Valerianella	-	-	-	-	-	-	-	0.1	-	-	0.4	-	-	-
Anthoceros laevis	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-
Dryopteris	0.1	-	-	0.1	0.1	0.2	0.3	-	0.1	-	0.1	0.1	-	-
cf. Osmunda	-	-	-	-	-	-	-	0.4	-	-	-	-	-	-
Pteridium	0.1	0.6	-	0.2	0.1	-	0.3	0.1	-	0.4	-	-	-	15.1
Pteris-type	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphagnum	-	-	-	-	0.1	-	-	-	-	0.1	-	-	-	-
Pollen sum	977	667	779	1490	712	1126	351	1477	1164	835	804	998	1189	1231

Table 4. Surface-sample spectra from the Oro-Mediterranean zone.

	Cedrus-Juniperus forest			disturbed vegetation			Abies forest			
Sample numbers	38	39	40	41	43	42	53	54	55	56
Σ AP	92.9	90.4	89.5	86.7	76.5	74.4	92.9	90.0	82.9	81.2
Abies	-	-	-	-	-	-	3.8	15.3	12.4	2.1
Acer	0.1	-	-	-	-	-	-	-	-	-
Alnus	-	-	-	-	0.1	0.1	1.4	0.1	0.1	0.1
Arceuthobium	-	-	0.2	-	-	-	0.1	0.1	0.1	-
cf. Berberis	-	-	-	-	-	-	-	-	-	0.1
Betula	-	-	-	-	-	-	0.1	-	-	-
Buxus	-	-	-	-	0.1	-	-	-	-	-
Carpinus betulus	-	-	0.1	-	-	-	0.1	0.2	-	0.1
Castanea	-	-	-	-	-	0.2	-	0.1	-	-
Casuarina	-	-	0.1	-	-	-	-	-	-	-
Cedrus	24.6	20.1	7.9	9.3	0.8	2.2	1.1	1.2	1.6	0.5
Ceratonia	-	-	-	-	-	-	-	-	0.1	-
Citrus	-	-	-	-	0.1	-	-	-	-	-
Corylus	-	-	-	0.1	0.2	-	-	-	-	-
Crataegus-type	-	-	-	-	-	0.1	0.2	0.1	0.5	2.8
Daphne	-	-	-	-	-	-	0.1	-	-	-
Eucalyptus	0.1	-	-	-	-	-	-	-	-	-
Fraxinus excelsior-type	-	0.1	-	-	0.1	-	-	-	-	-
Fraxinus ornus	-	0.1	-	-	-	-	-	-	-	-
Genista-type	0.1	0.1	-	-	-	-	-	-	-	-
Juglans	-	0.1	-	-	-	1.9	-	0.1	0.1	0.2
Juniperus	57.6	23.9	43.9	19.3	23.7	7.7	38.4	47.4	15.8	23.3
Juniperus sabina	-	-	-	-	-	-	-	0.4	-	0.2
Myrtus	-	-	-	-	-	-	0.1	-	-	-
Olea	0.2	0.5	0.2	0.2	0.3	0.5	0.4	0.3	-	-
Ostrya/Carpinus orientalis	0.1	1.1	0.2	0.2	0.3	0.3	2.0	3.4	2.0	0.4
Phillyrea/Fontanesia	0.1	0.1	0.2	0.1	0.3	0.3	1.5	1.3	0.7	0.4
Picea	-	-	-	-	-	-	0.1	-	-	-
Pinus	6.3	29.3	18.0	19.8	41.0	49.2	37.8	15.9	45.0	43.1
Pistacia	0.2	0.5	0.4	0.1	0.2	0.4	1.0	0.5	1.0	0.2
Platanus	-	-	-	-	0.3	0.3	0.1	0.4	0.5	0.2
Prunus-type	-	0.1	-	-	-	-	-	-	0.1	-
Quercus calliprinos-type	3.5	13.2	17.7	37.2	7.5	7.2	1.7	0.8	0.9	0.4
Quercus cerris/infectoria-type	0.3	1.2	0.6	0.5	1.3	1.1	3.1	2.4	1.9	5.8
Rhamnus	0.1	-	0.1	-	-	-	-	-	-	0.1
Rhus	-	-	-	-	-	-	0.1	-	-	-
Rubus-type	-	-	-	-	-	-	-	-	-	0.1
Salix	-	0.2	-	0.1	0.3	3.0	-	-	-	-
Styrax	-	-	-	-	0.1	-	-	-	-	-
Tamarix	-	-	-	-	-	-	-	-	-	0.1
Taxus	-	-	0.1	-	-	-	-	-	-	-
Ulmus	-	-	-	-	-	0.1	-	0.1	0.1	0.1
Vitis	-	-	0.1	-	-	-	0.1	-	-	-
Σ NAP	7.1	9.6	10.5	13.3	23.5	25.6	7.1	10.0	17.1	18.8
Echium-type	-	0.1	-	-	-	-	-	-	-	-
Heliotropium-type	0.1	0.1	-	-	-	-	-	0.1	-	-
Symphytum-type	-	-	-	-	-	0.2	-	-	0.1	-
Jasione-type	-	-	-	-	0.1	-	-	-	-	-
Humulus/Cannabis	-	0.1	-	-	-	-	0.1	0.1	-	-
Caryophyllaceae indet.	0.2	0.1	0.2	0.7	0.3	0.5	0.1	0.2	-	0.1
Chenopdiaceae indet.	0.2	0.4	0.2	0.1	0.3	0.6	0.3	0.3	0.4	0.1
Helianthemum	-	-	-	-	-	0.2	0.1	-	-	-
Artemisia	0.9	0.8	0.3	-	0.5	0.5	0.7	0.2	0.5	0.4
Centaurea cyanus-type	0.1	-	-	-	-	0.4	-	-	-	-
Centaurea scabiosa-type	-	-	-	0.3	0.1	-	-	-	-	-
Centaurea solstitialis-type	0.5	0.3	-	-	0.2	0.6	0.1	0.1	-	0.1

Table 4. cont'd

	Cedrus-Juniperus forest			disturbed vegetation			Abies forest			
Sample numbers	38	39	40	41	43	42	53	54	55	56
Cirsium-type	-	-	-	0.1	0.3	0.7	-	1.2	0.1	-
Filago-type	-	-	-	-	-	-	-	-	-	0.1
Liguliflorae indet.	1.4	0.4	0.5	0.7	1.4	2.4	0.4	2.1	0.2	1.9
Matricaria-type	0.2	0.2	0.2	2.3	1.2	2.4	0.4	0.1	0.4	1.2
Scorzonera-type	-	-	-	-	-	-	-	-	-	0.1
Senecio-type	-	-	-	0.1	0.2	-	-	-	0.1	-
Tubuliflorae indet.	-	0.2	0.1	1.8	0.3	0.8	0.1	0.2	0.1	0.2
Xanthium	-	-	0.1	-	-	-	0.1	-	-	-
Brassica-type	0.2	0.5	0.5	0.2	0.4	0.5	0.4	0.2	0.1	0.3
Capsella-type	-	-	-	-	-	-	-	0.1	0.1	-
Cyperaceae	0.1	0.4	0.2	0.1	0.3	0.3	0.1	0.3	0.2	0.5
Scabiosa columbaria-type	-	-	0.1	-	-	-	-	-	-	-
Ephedra distachya-type	0.1	0.1	-	-	-	0.1	-	-	-	-
Ephedra fragilis-type	0.1	0.1	0.1	0.1	0.1	-	-	-	-	-
Ericaceae	-	-	-	-	0.1	-	0.1	-	0.1	-
Euphorbia	0.1	0.1	0.1	-	-	-	-	-	-	0.1
Geranium	-	-	-	-	0.1	-	0.1	0.1	-	-
Gramineae indet.	1.9	1.8	1.1	5.0	14.6	7.8	2.3	2.9	6.6	5.4
Cerealia-type	0.1	0.7	0.1	0.1	1.6	1.1	0.5	0.1	1.0	2.1
Secale	-	-	-	-	0.8	0.2	-	-	-	0.4
Hypericum perforatum-type	-	-	0.1	-	-	-	-	-	-	-
Labiatae indet.	-	-	-	0.1	-	-	-	-	-	-
Phlomis	-	-	5.1	-	-	-	-	-	-	-
Stachys-type	-	-	-	-	0.1	0.2	-	0.1	-	-
Teucrium	-	-	-	-	-	-	0.1	-	-	-
Thymus-type	-	-	0.1	0.1	-	0.1	-	-	0.1	-
Leguminosae indet.	0.3	0.2	0.2	0.1	0.1	0.5	0.1	0.1	0.2	0.5
Lotus-type	-	-	0.1	-	-	-	-	-	0.1	0.1
Onobrychis-type	-	0.5	-	-	-	-	-	-	-	0.2
Trifolium-type	-	-	-	-	-	0.1	0.1	-	-	-
Vicia-type	-	-	0.1	-	-	-	-	-	-	-
Liliaceae indet.	-	-	-	-	-	0.1	-	-	-	-
Asparagus-type	-	0.1	-	-	-	-	-	-	-	-
Papaver	-	-	-	-	-	0.1	-	-	-	0.1
Plantago lanceolata-type	0.2	0.8	0.1	0.3	0.1	1.0	0.3	0.9	4.4	0.7
Polygonum aviculare-type	0.1	0.2	0.2	0.2	-	-	0.1	-	0.1	0.2
Rumex acetosa-type	-	-	0.5	-	-	-	-	-	0.1	-
Potamogeton	0.1	-	0.1	-	-	-	-	-	-	-
Anemone-type	-	-	-	-	-	0.1	0.1	-	-	0.3
Dephinium-type	-	0.1	-	-	-	0.1	-	-	-	-
Ranunculus repens-type	0.1	0.1	0.1	0.1	0.1	-	-	-	-	1.2
Ranunculus sceleratus type	-	-	-	-	0.1	-	-	-	-	-
Thalictrum	-	0.1	-	0.1	-	-	0.1	0.1	0.1	-
Sanguisorba minor-type	0.1	-	0.1	0.1	-	0.2	0.1	-	1.3	0.8
Galium-type	0.4	0.2	0.3	0.2	-	0.4	-	0.4	0.6	1.0
Thesium	-	-	-	-	-	0.1	-	-	-	-
Saxifraga oppositifolia-type	-	-	-	-	-	-	0.1	-	-	-
Digitalis-type	-	-	-	-	-	-	0.1	-	-	0.1
Rhinanthus-type	-	0.8	-	-	-	0.1	-	-	-	0.1
Scrophularia-type	0.2	0.1	-	-	0.3	0.2	-	-	-	0.1
Sparganium-type	-	0.1	-	0.1	-	-	0.1	0.2	0.1	-
Umbelliferae indet.	0.1	-	0.1	-	-	1.3	0.1	-	-	0.2
Bunium-type	0.1	-	-	0.2	-	1.2	-	-	-	-
Bupleurum-type	-	-	-	-	-	0.5	-	-	-	-
Eryngium-type	-	-	-	-	-	0.1	-	-	0.1	0.1
Ferula-type	-	-	-	-	-	0.1	-	-	-	-
Malabaila	-	-	-	-	-	-	-	-	-	0.2
Pimpinella-type	0.1	-	-	-	-	-	-	-	-	-
Turgenia	-	-	-	-	-	0.1	-	-	-	

Table 4. cont'd

	Cedrus-Juniperus forest			disturbed vegetation			Abies forest			
Sample numbers	38	39	40	41	43	42	53	54	55	56
Urtica dioica-type	-	-	-	-	-	-	0.1	-	-	-
Valerianella	-	-	-	0.1	0.1	-	-	-	-	0.1
Cheilanthes	-	-	-	-	-	-	-	-	-	0.1
Dryopteris	-	0.1	-	-	-	-	0.1	-	0.1	0.1
Pteridium	-	0.1	-	0.2	-	-	0.1	-	-	0.1
Pollen sum	1993	1305	1325	1070	1188	1314	1776	1596	1466	1120

Table 5. Surface-sample spectra from the Xero-Euxenian zone.

Sample numbers	58	60	59	57
Σ AP	78.6	70.8	29.9	26.6
Abies	-	-	-	0.2
Alnus	-	0.1	0.1	0.1
Arbutus	-	-	-	0.1
Betula	-	-	0.2	-
Carpinus betulus	-	0.2	0.1	
Castanea	0.2	0.7	-	0.1
Cedrus	-	0.1	-	0.3
Corylus	0.3	-	0.1	0.1
Cotoneaster	-	0.1	-	-
Crataegus-type	3.6	-	-	0.1
Elaeagus	-	-	-	0.1
Fraxinus ornus	0.3	0.1	-	-
Juglans	0.4	0.3	-	-
Juniperus	15.1	41.7	3.0	4.9
Libocedrus	-	-	-	0.1
Olea	0.1	0.6	0.2	0.3
Ostrya/Carpinus orientalis	0.1	0.1	-	0.1
Phillyrea/Fontanesia	0.1	0.5	0.2	0.1
Pinus	12.2	21.0	24.4	17.3
Pistacia	0.1	0.1	-	0.1
Platanus	0.2	0.3	-	0.2
Populus	0.1	-	-	-
Prunus-type	0.2	-	-	-
Quercus calliprinos-type	22.0	1.2	0.3	0.8
Quercus cerris/infectoria-type	23.1	3.4	1.1	1.6
Salix	0.3	0.1	0.2	0.1
Ulmus	0.1	0.1		0.1
Vitis	0.1	0.1	-	0.1
Σ NAP	21.4	29.2	70.1	73.4
Echium-type	-	0.1	-	0.1
Heliotropium-type	-	-	-	0.1
Symphytum-type	-	0.1	0.1	-
Humulus/Cannabis	0.1	0.1	-	0.1
Caryophyllaceae indet.	-	0.4	0.3	0.2
Spergula	-	-	0.1	-
cf. Spergularia	0.9	-	0.1	-
Chenopodiaceae	1.2	2.0	2.0	1.5
Helianthemum	0.6	0.1	0.2	-

Table 5. cont'd

Sample numbers	58	60	59	57
Artemisia	2.5	4.2	7.4	34.3
Carthamus-type	-	-	0.1	-
Centaurea cyanus-type	0.1	0.3	0.4	0.3
Centaurea scabiosa-type	-	0.2	0.2	-
Centaurea solstitialis-type	0.3	0.3	3.6	0.2
Cirsium-type	0.2	0.1	0.7	0.1
Filago-type	-	0.1	-	0.1
Liguliflorae indet.	0.2	1.7	3.2	4.9
Matricaria-type	1.8	0.3	10.1	2.7
Scorzonera-type	-	-	-	0.1
Senecio-type	-	1.1	0.2	0.6
Tubuliflorae indet.	0.2	0.4	2.1	0.4
Brassica-type	0.4	0.5	2.0	0.4
Capsella-type	-	-	3.1	-
Citrullus	0.1	-	-	-
Cyperaceae	0.5	0.6	0.9	2.3
Scabiosa palaestina-type	-	-	0.1	-
Ephedra distachya-type	0.1	-	0.1	-
Ericaceae	-	-	-	0.1
Erodium	-	-	-	0.1
Geranium	0.1	-	-	-
Gramineae indet.	6.0	6.8	13.9	17.0
Cerealia-type	0.2	5.7	4.2	2.2
Secale	-	-	0.1	-
Zea mays	-	-	-	0.1
Myriophyllum spicatum/verticillatum	0.1	-	-	-
Sisyrhynchium	-	-	-	0.1
Leguminosae indet.	0.8	0.5	0.7	0.6
Lotus-type	0.2	0.1	-	-
Onobrychis-type	-	-	0.2	-
Ononis-type	0.5	-	-	-
Trifolium-type	0.5	0.1	0.2	-
Vicia-type	0.5	-	-	-
Allium	-	-	0.8	-
Scilla-type	0.1	-	-	-
Glaucium	-	-	-	0.1
Plantago lanceolata-type	0.9	0.9	0.6	0.8
Limonium-type	-	-	0.1	-
Polygonum aviculare-type	0.1	0.1	0.2	0.1

Table 5. cont'd

Sample numbers	58	60	59	57
Rumex acetosa-type	0.2	0.3	0.1	-
Potamogeton	-	-	-	0.1
Caltha	0.1	-	-	-
Nigella	0.2	-	0.2	-
Ranunculus repens-type	0.4	-	0.2	-
Ranunculus sceleratus-type	-	-	-	0.1
Thalictrum	0.1	0.1	0.1	0.1
Sanguisorba minor-type	0.1	0.1	-	0.1
Galium-type	0.7	0.5	0.2	0.1
Saxifraga stellaris-type	0.1	-	-	-
Digitalis-type	-	0.1	-	-
Rhinanthus-type	0.2	-	-	-
Scrophularia-type	0.1	0.4	-	0.1
Sparganium-type	0.1	0.1	0.2	2.1
Umbelliferae indet.	0.1	0.1	0.2	0.1
Anisosciadium	-	-	0.1	-
Bunium-type	0.1	0.3	0.1	-
Bupleurum-type	-	-	10.0	-
Eryngium-type	-	-	0.4	0.9
Ferula-type	-	-	0.1	-
Malabaila	-	-	0.1	-
Urtica dioica-type	-	0.1	0.1	-
Valerianella	-	-	0.2	-
Peganum harmala	-	-	-	0.1
Pteridium	-	0.2	0.1	-
Pollen sum	1213	1464	1226	1559

Table 6. Surface-sample spectra from southwestern Turkey. For a selected number of pollen types the mean percentages and frequencies per sub-group are given. For explanation see 6.1.

	Pinus forest						Maquis			
	0-300 m		300-800 m		800-1200 m		0-300 m		300-800 m	
∑ AP	88.2		86.1		87.2		69.8		77.8	
Abies	-		0.1	1/8	-		0.1	1/3	-	
Alnus	1.3	4/5	0.4	4/8	2.0	2/4	0.6	3/3	0.2	5/5
Cedrus	-		0.1	2/8	0.1	1/4	0.1	1/3	0.2	2/5
Fraxinus ornus	-		0.3	1/8	-		0.1	2/3	3.9	1/5
Juglans	0.4	2/5	0.2	5/8	0.2	3/4	0.3	3/3	0.2	4/5
Juniperus	0.7	4/5	0.8	7/8	2.0	4/4	0.3	3/3	2.3	5/5
Liquidambar	3.3	3/5	0.1	2/8	0.2	1/4	-		0.1	2/5
Olea	4.6	5/5	5.2	8/8	0.8	4/4	12.3	3/3	8.2	5/5
Ostrya/Carpinus orientalis	0.1	2/5	0.1	3/8	0.1	1/4	0.1	2/3	0.1	3/5
Phillyrea/Fontanesia	0.6	5/5	1.5	8/8	0.2	1/4	1.1	3/3	11.6	5/5
Pinus	69.7	5/5	65.6	8/8	75.9	4/4	20.8	3/3	25.7	5/5
Pistacia	0.4	5/5	1.3	8/8	0.3	1/4	3.5	3/3	2.5	4/5
Platanus	0.2	5/5	0.6	6/8	1.0	3/4	3.6	3/3	0.2	4/5
Quercus cerris/infectoria-type	1.1	5/5	2.2	8/8	3.6	4/4	1.9	3/3	2.7	5/5
Quercus calliprinos-type	7.3	5/5	7.6	8/8	2.1	4/4	24.0	3/3	22.6	5/5
Salix	0.1	3/5	0.1	3/8	0.1	1/4	0.3	3/3	0.2	2/5
∑ Chenopodiaceae	0.6	5/5	0.6	8/8	0.7	3/4	1.2	2/3	0.5	5/5
∑ Cistaceae	1.4	2/5	0.7	5/8	0.2	3/4	1.8	2/3	0.9	3/5
Artemisia	0.4	5/5	0.4	8/8	1.4	3/4	0.2	3/3	0.4	4/5
Centaurea solstitialis-type	0.2	3/5	0.2	5/8	0.4	4/4	0.2	3/3	0.4	2/5
∑ Tubuliflorae[1]	0.4	5/5	0.8	8/8	0.5	4/4	1.6	3/3	1.0	5/5
∑ Liguliflorae	0.4	5/5	1.1	7/8	0.8	4/4	5.8	3/3	1.9	5/5
∑ Cruciferae	0.4	4/5	0.4	7/8	0.6	3/4	0.3	3/3	1.0	5/5
Cyperaceae	0.2	5/5	0.5	6/8	1.1	3/4	1.8	3/3	0.5	4/5
∑ Ephedra	0.2	1/5	0.1	3/8	0.1	2/4	0.2	1/3	0.1	2/5
Ericaceae	3.2	4/5	3.5	6/8	-		0.4	3/3	3.6	3/5
Gramineae	2.7	5/5	1.9	8/8	1.7	4/4	4.4	3/3	7.0	5/5
∑ Cerealia-type	0.5	2/5	0.3	5/8	0.7	4/4	0.4	3/3	0.5	5/5
Plantago lanceolata-type	0.4	5/5	0.5	8/8	1.1	4/4	5.9	3/3	1.4	5/5
Polygonum aviculare-type	0.2	2/5	0.1	2/8	0.1	1/4	-		0.2	1/5
Rumex acetosa-type	0.2	3/5	0.3	7/8	0.3	3/4	0.9	3/3	0.4	3/5
Sanguisorba minor-type	0.4	3/5	0.6	5/8	0.3	3/4	0.5	2/3	0.2	2/5
Sparganium-type	0.3	5/5	0.2	7/8	0.1	3/4	0.6	2/3	0.3	4/5
∑ Umbelliferae	1.1	5/5	0.4	6/8	0.5	2/4	1.9	3/3	1.4	5/5

[1]Artemisia, Centaurea and Xanthium not included

Seriously disturbed vegetation						Cedrus-Juniperus forest		Abies forest	
0-300 m		300-800 m		800-1200 m					
38.9		65.1		60.9		90.9		88.6	
-		0.5	2/6	0.1	3/7	-		10.5	3/3
0.2	2/2	0.2	5/6	0.3	4/7	-		0.5	3/3
-		0.7	1/6	0.3	5/7	17.5	3/3	1.3	3/3
-		0.2	2/6	0.2	4/7	0.1	1/3	-	
0.2	2/2	3.7	5/6	0.6	6/7	0.1	1/3	0.1	2/3
0.2	2/2	2.6	5/6	3.4	7/7	41.8	3/3	33.9	3/3
0.1	1/2	0.7	1/6	0.2	2/7	-		-	
8.4	2/2	5.7	6/6	0.8	7/7	0.3	3/3	0.4	2/3
-		0.5	2/6	0.2	5/7	0.5	3/3	2.5	3/3
0.5	2/2	1.1	6/6	1.0	5/7	0.1	3/3	1.2	3/3
10.6	2/2	32.3	6/6	41.2	7/7	17.9	3/3	32.9	3/3
0.4	2/2	1.0	6/6	0.6	7/7	0.4	3/3	0.8	3/3
0.1	2/2	2.1	6/6	0.4	5/7	-		0.3	3/3
1.7	2/2	2.3	6/6	2.4	7/7	0.7	3/3	2.5	3/3
15.3	2/2	13.7	6/6	6.9	7/7	11.5	3/3	1.1	3/3
0.7	2/2	0.3	2/6	2.1	7/7	0.2	1/3	-	
0.9	2/2	0.6	6/6	1.2	7/7	0.3	3/3	0.3	3/3
0.1	1/2	0.8	3/6	0.1	1/7	-		0.1	1/3
0.2	2/2	0.7	5/6	2.3	7/7	0.7	3/3	0.5	3/3
0.3	2/2	0.2	5/6	1.6	7/7	0.4	2/3	0.1	2/3
2.0	2/2	1.4	6/6	2.9	7/7	0.3	3/3	0.9	3/3
3.6	2/2	5.1	6/6	2.1	7/7	0.8	3/3	0.9	3/3
1.4	2/2	2.0	6/6	1.7	6/7	0.4	3/3	0.3	3/3
0.5	2/2	2.1	4/6	0.7	7/7	0.2	3/3	0.2	3/3
-		0.1	1/6	0.1	2/7	0.2	3/3	-	
0.1	2/2	0.2	2/6	0.2	1/7	-		0.1	2/3
4.1	2/2	9.8	6/6	10.7	7/7	1.6	3/3	3.9	3/3
0.6	2/2	1.1	6/6	6.0	7/7	0.3	3/3	0.5	3/3
38.4	2/2	6.2	6/6	3.0	7/7	0.4	3/3	1.9	3/3
-		0.2	1/6	0.2	5/7	0.2	3/3	0.1	2/3
5.3	2/2	0.8	5/6	0.4	6/7	0.5	1/3	0.1	1/3
-		0.1	4/6	0.3	4/7	0.1	2/3	0.7	2/3
0.1	1/2	0.2	5/6	0.3	6/7	0.1	1/3	0.1	3/3
0.3	2/2	1.2	6/6	1.1	7/7	0.2	2/3	0.1	2/3

ranean pine forests, but also those from other vegetation types included in this study suggest that *Olea* has a good production as well as dispersal of pollen.

At some distance from the locality of sample 13, an *Alnus-Liquidambar* grove occurred alongside a rivulet, which explains the fairly high pollen values for alder and amber tree (4.2 and 9.2%) respectively) in the sample concerned. *Liquidambar orientalis* is found in southwestern Turkey in flood plains, river valleys and other marshy places, at elevations between sea-level and 800 m (Davis 1972, p. 264).

A large number of herbaceous species and low shrubs is represented in the pollen spectra from the pine forests, although usually in low percentages and often only in one or a few spectra of this sub-group. Occasionally a somewhat higher percentage was obtained, which must be ascribed to local factors. Thus, the common occurrence of *Erica verticillata* in the vegetation of the site where sample 9 was taken must account for the large share of Ericaceae (12.5%) in the local pollen rain. It should be taken into consideration that the comparatively high average value of 3.2% for Ericaceae in sub-group *a* (table 6) is due to this isolated high percentage for this pollen type.

The spectra from the maquis of the lower Eu-Mediterranean zone (sub-group *b*) are characterized by high values for *Quercus calliprinos*-type pollen. In view of the dominance of kermes oak in the shrub vegetations concerned this high pollen representation is according to expectation. *Phillyrea* and particularly *Pistacia* are, on the average, somewhat better represented in the spectra from the maquis than in those from the pine forests. Most of the *Olea* pollen in sample 7 will have originated from the olive yards at a short distance from the sampling locality. Just as for Ericaceae in sub-group *a*, the anomalously high *Olea* pollen percentage in sample 7 increases the average value for this pollen type in sub-group *b* (12.3%) quite considerably. *Platanus* was common in the river valley where sample 7 was taken, which explains the pollen value of 9.5%.

The herbaceous pollen percentages in the spectra of sub-group *b* are, on the average, higher than those in the spectra from the pine forest. However, the level of the herbaceous pollen percentages in the individual samples may have depended more on the very local plant growth than on the general vegetation type. Thus, the average percentage for Gramineae is higher in the samples from the maquis than in those from the pine forest, but the highest Gramineous pollen value was found in sample 12 from the pine forest. In the three samples from the maquis, the pollen values for Liguliflorae Compositae are significantly higher than in samples from the pine forest, but a similar difference was not obtained for the spectra from the corresponding vegetation types in the upper Eu-Mediterranean zone (table 2, sub-groups *a* and *b*). Sample 36, from an open, heavily grazed maquis, yielded much *Plantago lanceolata*-type pollen (16.4%).

In both samples from areas with a seriously degraded vegetation (sub-group *c*) the herbaceous pollen percentages are high. Of the tree pollen types, *Olea*, *Pinus* and *Quercus calliprinos* show the highest values. The much better representation of *Quercus calliprinos* in sample 20 as compared to sample 21 must be ascribed to the circumstance that in the area of the former sample scattered kermes oak was present, whereas no shrubs were observed in the vicinity of the locality of sample 21. The nevertheless fairly high percentage for *Quercus calliprinos*-type in spectrum 21 indicates that in kermes oak the production as well as the dispersal of pollen is good.

The high *Olea* pollen percentages in both samples of sub-group *c* must be ascribed to the presence of olive yards, whereas, on the other hand, wild trees and shrubs had largely or completely disappeared from the area.

The higher ΣNAP percentages in both spectra of sub-group *c* as compared to those of sub-group *b* are mainly accounted for by the *Plantago lanceolata*-type pollen. In samples 20 and 21 the percentages for Gramineae and other herbs are not higher than in those from the maquis. Only *Rumex* shows 9.9% in sample 20, which must be due to local over-representation. Spectra 20 and 21, and also spectrum 36 (sub-group *b*), seem to suggest that high *Plantago lanceolata*-type pollen values are indicative of open, grazed terrain. However, the analysis of samples from similar vegetations in other zones (tables 2 and 5) suggests that apparently grazing does not necessarily lead to an expansion of plantain.

Sample 14 originates from a rock outcrop in the marshy area alongside the southeastern shore of Köyceğiz Gölü (fig. 21). This sample was taken to provide information on the present-day pollen precipitation in the area of the Köyceğiz sediment core (7.6.). The local vegetation was affected by grazing. *Tamarix* is a common shrub in the marshes, while *Ficus*, *Colutea*, *Vitex* and *Paliurus* were observed on, and at the foot of, the rock outcrop. The rocky slopes west and southwest of the lake, at a distance of 2.5 km and more from the surface-sample site, are covered by *Pinus brutia* forest and maquis with predominantly *Quercus calliprinos*.

Of the local shrubs, only *Paliurus* is fairly well represented in the pollen precipitation (4.0%). In spite of the common occurrence of *Tamarix* in the marsh vegetation, its pollen value amounts to only 0.8%. *Pinus* shows the highest percentage (35.4%) of all pollen types in sample 14, which, once again, demonstrates the good pollen dispersal of pine.

The high *Sparganium*-type pollen percentage (12.5%) must have been effected by bur-reed in the local marsh vegetation. A Leguminous pollen type which was found in very large numbers (19.8%) is puzzling. This type cannot have originated from *Colutea arborea*, which shrub formed part of the vegetation of the rock outcrop.

6.4. *THE UPPER EU-MEDITERRANEAN ZONE*

Just like the surface samples from the lower Eu-Mediterranean zone, those from the upper Eu-Mediterranean zone are arranged in three sub-groups (table 2):

a. 8 samples from *Pinus brutia* forests and forest remnants.

b. 5 samples from maquis.

c. 6 samples from predominantly open terrain.

As is clear particularly from table 6, the pollen precipitation in the pine forests of the upper Eu-Mediterranean zone shows a marked resemblance to that in the lower Eu-Mediterranean pine forests. *Pistacia*, *Phillyrea/Fontanesia* and *Quercus cerris/infectoria*-type show, on the average, slightly higher values in the pine forests of the upper Eu-Mediterranean zone, which is mainly due to relatively high percentages in one or two samples.

The poor pollen representation of *Styrax officinalis* is, once again, demonstrated in sample 15. In spite of the predominant role of *Styrax* in the undergrowth of the pine forest in the locality of sample 15, *Styrax* pollen amounts to only 0.5%.

It should be stressed that neither the tree pollen values, nor the herbaceous pollen values in the samples from the upper Eu-Mediterranean pine forest differ significantly from those in the samples from the corresponding forest at lower elevations. Consequently, pollen analytically no distinction can be made between the pine forests of both Eu-Mediterranean zones.

In the upper Eu-Mediterranean zone, as in the lower Eu-Mediterranean zone, the spectra from the maquis show usually much higher *Quercus calliprinos*-type values and much lower *Pinus* percentages than the spectra from the pine forest. A marked difference between the pollen spectra from the maquis of the lower and the upper Eu-Mediterranean zone is caused by the *Phillyrea/Fontanesia*-type. In 3 of the 5 samples from the upper Eu-Mediterranean maquis (table 2, sub-group *b*) this pollen type shows conspicuously high percentages which must be ascribed to the predominant role of *Phillyrea* in the local vegetation. In the locality of sample 46 *Fontanesia phillyreoides* was observed. Although *Phillyrea/Fontanesia*-type pollen is not common in all samples from the upper Eu-Mediterranean maquis, high values for this pollen type may be expected in spectra from this vegetation type particularly.

Some attention should be paid to the 3.9% *Fraxinus ornus* pollen in sample 46. This high pollen value is all the more striking as no manna ash or another type of ash was observed in the vicinity of sampling site 46. It is quite possible that *Fraxinus ornus* was overlooked in the hasty vegetation survey of the area, but this species would certainly not have been common. A pollen value of 3.9% suggests that the pollen production and dispersal of the manna ash must be quite good. In the other surface samples *Fraxinus ornus* is scarcely represented (low frequency, low percentages).

Olive (wild or escaped from cultivation) formed part of the maquis where sample 46 was taken, which explains its pollen value of 21.0%. *Arbutus* is clearly under-represented in the pollen precipitation. *Arbutus unedo* was an important constituent of the maquis where sample 2 was taken, but its pollen value in the corresponding spectrum amounts to only 0.7%. *Arbutus andrachne* was common near the locality of sample 47, but its share in the local pollen rain is only 0.3%.

As has already been remarked in the discussion of the spectra from the lower Eu-Mediterranean maquis, the herbaceous pollen precipitation depends particularly on local conditions. As a result, the percentages for herbaceous pollen types vary considerably in the spectra from the upper Eu-Mediterranean maquis (*e.g.* Gramineae, Umbelliferae, Liguliflorae Compositae).

In the spectra from areas under intensive cultivation (table 2, sub-group *c*) both herbaceous pollen types and tree pollen types show considerable fluctuations, in consequence of which mean pollen values should be considered with some reservation. The fluctuations in the tree pollen percentages can mostly, but not always, be understood by the nature of the vegetation in the vicinity of the sampling sites. In general, the *Pinus* pollen values are fairly high; either scattered pine trees were observed in the area or pine forest remnants were found at some distance from the sampling site. On the other hand, no reasonable explanation can be presented for the conspicuously low *Pinus* pollen value (3.2%) in sample 22.

The mean *Juniperus* pollen values for the spectra from the maquis and open vegetations in the upper Eu-Mediterranean zone are higher than those from the corresponding vegetations in the lower Eu-Mediterranean zone (table 6). From tables 1 and 2, sub-groups *b* and *c*, it appears that higher juniper pollen values have indeed only been obtained for samples from more or less seriously degraded vegetations in the upper Eu-Mediterranean zone. On the other hand, very low values for this pollen type are not confined to the lower Eu-Mediterranean zone.

Although evidence for intensive grazing was quite obvious in the areas of samples 17, 19, 25, 51 and 52, a high *Plantago lanceolata*-type pollen percentage was only obtained for sample 25. This indicates that grazing does not necessarily lead to a strong expansion of plantain and subsequently to a large share of *Plantago* in the local pollen precipitation.

6.5. THE ORO-MEDITERRANEAN VEGETATION ZONE

The natural forest vegetation of the Oro-Mediterranean zone is by no means homogeneous, but various forest types can be distinguished. Because of the variation in natural forest cover, the spectra from the Oro-Mediterranean zone are divided into two major groups. One group (table 3) comprises the samples from the Oro-Mediterranean pine forest and its degradation stages. The other group (table 4) consists of samples from cedar-juniper and fir forest areas.

6.5.1. THE ORO-MEDITERRANEAN PINE FOREST AREA

The samples from the Oro-Mediterranean pine forest area are arranged in two sub-groups (table 3):

a. 4 samples from forests with predominantly pine (*Pinus brutia* as well as *P. nigra*).

c. 7 samples from areas which are completely or largely devoid of trees and shrubs (fields, heavily grazed terrains).

The samples 33, 44 and 24, to the right of the table, are from vegetations which do not fit into either of the two sub-groups and which differ from each other quite markedly.

The tree pollen precipitation in the Oro-Mediterranean pine forests shows some differences with that in the pine forests of the Eu-Mediterranean zones, which is particularly clear from table 6. The most conspicuous difference is constituted by *Olea*, which shows here an average pollen value of 0.8% as against 4.6 and 5.2% in the Eu-Mediterranean pine forests. The mean *Quercus calliprinos*-type pollen value (2.1%) is also significantly lower than those in the Eu-Mediterranean pine forests (7.3 and 7.6%). We should, however, take into account the fact that *Quercus calliprinos*-type pollen percentages in various samples from the Eu-Mediterranean pine forests (tables 1 and 2) are not higher than in the samples from the Oro-Mediterranean pine forests. The higher mean *Juniperus* and *Quercus cerris/infectoria*-type pollen values as compared to those in the Eu-Mediterranean pine forests (table 6) are mainly due to the comparatively high percentages for these pollen types in sample 27.

The differences between the mean pollen precipitation of seriously disturbed areas in the Oro-Mediterranean pine forest zone and in the Eu-Mediterranean zones are largely comparable to the differences between the pollen spectra from the forests of the corresponding zones (table 6). Thus, the mean *Olea* and *Quercus calliprinos*-type percentages are lower and the average *Pinus* pollen values are higher than in the spectra from disturbed areas in the Eu-Mediterranean zones.

The mean *Artemisia* pollen percentage is higher than in the spectra from disturbed areas in the upper Eu-Mediterranean zone. It is true that the difference in mean percentage is not great, but, on the other hand, a comparison of the *Artemisia* values in the individual spectra of both sub-groups (tables 2 and 3) shows that this difference is fairly consistent and not due to one or two exceptionally high values. The mean value of 1.6% for *Centaurea solstitialis*-type pollen constitutes a distinct increase as compared to the mean values for this pollen type in the spectra from seriously degraded vegetations in the Eu-Mediterranean belts. Higher pollen values for *Artemisia* and *Centaurea solstitialis*-type, a type which includes various *Centaurea* species, seem to be indicative of open vegetations at higher elevations.

The comparatively large numbers of *Cannabis/Humulus* pollen in samples 48 and 35 (3.7 and 5.4%) must have originated from *Cannabis* fields. In the area of sample 48 hemp was cultivated; this crop plant was not observed in the vicinity of sampling locality 35, but it may have been grown there in previous years. Although in the areas of most of the samples grazing took place, only sample 49 yielded a high *Plantago lanceolata*-type pollen value (11.0%). A similar result was obtained for the samples from seriously degraded vegetations in the upper Eu-Mediterranean zone.

The spectrum obtained for sample 33 differs from the average pollen values for sub-group *b* mainly in the higher *Juniperus* and *Quercus cerris/infectoria*-type pollen values. In the area of sample 33 well-developed deciduous oaks were found, among others in cultivated fields, while small trees as well as shrubs of *Juniperus oxycedrus* were observed.

Scattered small trees of *Juniperus excelsa* (up to 4 m high) and the predominance of juniper in the very open shrub vegetation in the area of sample 44 explain the high *Juniperus* pollen percentage. Moreover, a suitable moss sample could only be found in the vicinity of a small juniper shrub. Striking is the pollen value of 2,6% for *Arceuthobium*, a parasite on juniper.

Sample 24 is from an area where a *Pinus nigra* forest had been cut only a few years ago. The sampling site is situated ca. 2,000 m from extant pine forest (sample 23). The dominance of *Pteridium aquilinum* in the vegetation on the cleared terrain is reflected in the local pollen precipitation by 15.1% bracken, by far the highest percentage for this fern recorded in the surface samples from southwestern Turkey. *Cistus* spec. was also common in the local vegetation (pollen value 1.4%).

6.5.2. CEDAR-JUNIPER AND FIR FOREST AREAS

The surface-sample spectra of table 4 are arranged in two groups. The first group (to the left) consists of spectra from the Avlan Gölü-Elmali area, where the natural vegetation is made up of *Cedrus libani-Juniperus excelsa* forests (4.3.). Samples 38, 39 and 40 were taken in or near well-developed cedar-juniper forest; samples 41, 43 and 42 are from areas with increasingly degraded vegetation.

Cedrus as well as *Juniperus* pollen values show conspicuous fluctuations in the samples from the cedar-juniper forest. Although *Cedrus* and *Juniperus* are about equally common in the forest vegetation, juniper pollen percentages are much higher than those of cedar in two of the three samples. This could indicate that juniper is proportionally better represented in the pollen precipitation than cedar. On the other hand, one should be cautious in drawing conclusions of this kind from only a few spectra, particularly if strictly local factors may have influenced the pollen rain considerably. In this case the location of the patches of moss used as surface sample relative to the nearest cedar and juniper trees may have determined the pollen values for both species to a great extent.

In sample 38, from inside the forest, the *Pinus* percentage is low (6.3%), whereas in both samples from the edge of the forest the percentages for this pollen type are three to five times as high. This seems to indicate that directly outside the forest the share of the regional pollen in the pollen precipitation has already increased considerably.

At the forest edge *Quercus calliprinos* is better developed than inside the forest, a fact which is also reflected in the much higher values for the pollen type concerned in samples 39 and 40. Although *Acer* shrub was observed at a short distance from the site where sample 40 was taken, this species is not represented in the spectrum concerned. Sample 38 yielded one pollen grain of *Acer*, while *Acer* cf. *monspessulanum* formed part of the shrub vegetation in the cedar-juniper forest. From this and from other observations it is clear that *Acer* is seriously under-represented in the pollen precipitation.

Forests with cedar were not found close to the locality of sample 41. The *Cedrus* pollen value of 9.3% in spectrum 41 suggests that the dispersal of this pollen type is quite good, although it is inferior to that of *Pinus*.

The high ΣAP percentage in sample 41 is to a high degree due to the fairly well-developed juniper-kermes oak shrub vegetation which could develop after the cutting of the forest. On the other hand, at first sight it is astonishing that sample 42, which is from a slope completely devoid of trees and shrubs, yielded 74.4% arboreal pollen. This must be ascribed to the fact that the pollen production of the local vegetation was low, so that pollen originating from a greater distance made up the greater part of the pollen precipitation. As a result of erosion a considerable part of the surface consisted of barren rocks, while further serious over-grazing must greatly have prevented the extant vegetation from flowering. The 3% *Salix* pollen in this sample will have originated from willows which, in addition to poplar, grape and fruit trees, were growing in a small valley at a short distance from the sampling site.

Deciduous oak, *Ostrya/Carpinus orientalis*, *Olea* and *Phillyrea/Fontanesia* are represented in all samples from the Avlan Gölü-Elmali area, although the species concerned were not observed there. It is possible that these trees and shrubs have not been encountered because of the superficial study of the vegetation, but they could at most have played a very modest part in the forest vegetation. Particularly the representation of these species in sample 42, at a great distance from forest vegetations, suggests that they have a good pollen dispersal.

Samples 53, 54 and 55 (table 4, to the right) are from an area with extensive *Abies cilicica* forests, north of Akseki (fig. 7). The most striking feature of the spectra obtained for the samples from the fir forest is the poor representation of *Abies*. Irrespective of the anomalously low *Abies* pollen value of 3.8% in sample 53, values of 12.4 and 15.3% are surprisingly low in samples from an area where the forest consists for 90% and more of fir.

Although *Juniperus* does not play a prominent role in the *Abies* forests, its pollen percentages are quite high. For sample 54 it should be noted that a large juniper shrub was present at a short distance from the sampling site, which might explain 47.4% *Juniperus* pollen. However, the same does not hold true for samples 53 and 55. The low *Cedrus* pollen values are in accordance with the minor share of cedar in the forest vegetation. *Pinus* pollen values are, again, fairly high, although only in the area where sample 55 was taken does some *Pinus nigra* occur in the *Abies cilicica* forest.

In the area of sample 54, *Ostrya carpinifolia* was observed, which explains the fairly high value of 3.4% for the *Ostrya/ Carpinus orientalis*-type pollen in this sample. One may assume that this tree was not confined to the immediate vicinity of sampling site 54 (2.0% pollen in spectra 53 and 55). The same must be true for *Pistacia* cf. *terebinthus* and shrubby *Quercus cerris* which also formed part of the vegetation near the locality of sample 54.

The higher ΣNAP value in spectrum 55 as compared to spectra 53 and 54 is mainly accounted for by higher percentages for Gramineae, *Plantago lanceolata*-type and *Sanguisorba minor*-type. In particular, the relatively high plantain pollen frequency could point to grazing. The locality of sample 55 was an open place in the fir forest.

The poor representation of Ericaceae in the spectra from Oro-Mediterranean vegetations (tables 3 and 4) is in accordance with the fact that in southwestern Turkey, Ericaceae are confined to

Eu-Mediterranean vegetations.

Sample 56 is from the south side of Beyşehir Gölü, from an area which is partly in use as grazing land and partly as arable land. Between the *Abies* forest area of samples 53, 54 and 55 and the south shore of Beyşehir Gölü, a vegetation belt with predominantly *Pinus nigra* is present. For that reason it might have been better if sample 56 had been included in table 3 (Oro-Mediterranean pine forests). However, from a geographical point of view this sample, which is of special interest in connection with the pollen diagram prepared from the Beyşehir core (7.3.), links up better with the samples from the fir forest.

In spite of the predominantly open vegetation the ΣAP value is high (81.2%). This is due to *Pinus,* the pollen of which must have been transported over at least several kilometres, to *Juniperus* which occurs in the shrub vegetation of the area, and to *Quercus.* The deciduous oak pollen type (6.8%) must have originated mainly from scattered trees of *Quercus* cf. *pubescens*, but part of it may have been produced by deciduous oak shrub. *Quercus calliprinos*-type pollen shows a conspicuously low percentage (0.4%), which is in accordance with the fact that kermes oak was not observed in the area. Although the nearest stands of *Abies cilicica* are found at a distance of at least 15 km from the locality of sample 56, this tree has a pollen value of 2.1%. This would suggest that *Abies* pollen, once it has arrived in an air current above the tree canopy, may easily be transported over a longer distance.

6.6. *THE XERO-EUXINIAN VEGETATION ZONE*

Only a few surface samples are available from the Xero-Euxinian vegetation zone (table 5). Moreover, the samples are from different vegetation types, in consequence of which the pollen spectra concerned differ considerably from each other. Sample 58 is from the foot of a slope covered by dense shrub and small trees of predominantly *Quercus pubescens* and *Quercus calliprinos*, which is reflected in the high pollen values for both oak species. Sample 60, on the other hand, was taken in an open, grazed *Juniperus excelsa* shrub vegetation, which explains the 41.7% juniper pollen.

The tree pollen percentages in samples 59 and 57, both from a treeless area, do not show conspicuous differences. The greater part of the tree pollen is made up of that of *Pinus.* Further, *Juniperus* is fairly well represented in the pollen rain. It is clear that the tree pollen must have originated at a considerable distance from the sampling localities. The herbaceous pollen percentages in samples 59 and 57 show striking differences, which should, at least in part, be due to the different use of the land. Sample 59 is from an area with predominantly fields, whereas sample 57 is from heavily grazed terrain.

The high *Artemisia* pollen value in sample 57 is in accordance with the prominent role of *Artemisia* cf. *fragrans* in the local vegetation. Sample 59 shows a fairly high *Artemisia* pollen percentage, while more than 10% of the herbaceous pollen in samples 58 and 60 is made up of *Artemisia.* The present surface-sample study provides the following picture with regard to the representation of *Artemisia* in the pollen precipitation. *Artemisia* pollen was met with in nearly all samples from the lower and upper Eu-Mediterranean vegetation belts, but always in insignificant percentages. In the pollen precipitation in the Xero-Euxinian zone, on the other hand, the share of *Artemisia* is high to fairly high. The Oro-Mediterranean vegetation belt occupies an intermediate position in this respect. Low *Artemisia* percentages were established for the cedar-juniper forest and its degradation stages and for the fir forest, whereas the samples from the Oro-Mediterranean pine forest, and in particular from the seriously degraded vegetations in the pine forest area, yielded higher percentages for this pollen type.

Plantago lanceolata-type remains under 1% in the samples from the Xero-Euxinian zone, although heavy grazing took place in the areas of samples 57 and 60.

Because of the rather meagre pollen evidence for the Xero-Euxinian zone no further comparisons with palynological data from other vegetation zones will be made here.

7. THE SEDIMENT CORES

7.1. *INTRODUCTION*

In this chapter the pollen diagrams prepared from the sediment cores from southwestern Turkey will be discussed separately. A comparison of the results obtained for the individual sites and some general conclusions on the development of vegetation and climate during the time span covered by this investigation will be made in chapter 8.

In connection with the construction of the pollen diagrams the following remarks should be made here. The pollen sum includes the pollen of trees and shrubs and that of herbs from the upland vegetation. The latter category gives rise to some problems as taxa may be represented in the local as well as in the regional vegetation. One example is constituted by Gramineae. If there are distinct indications that the Gramineous pollen in a greater part of the sediment core is mainly of local origin, this pollen type is not included in the sum (Söğüt, Köyceğiz). For other taxa, such as Cyperaceae, *Sparganium* and *Typha latifolia*, there can be no doubt that they formed part of the local marsh vegetation. Similarly the pollen of water plants is of local origin. In addition to the pollen of marsh and water plants, some other pollen types are not included in the pollen sum because of probable local origin. Thus, high values for unidentified Tubuliflorae and Liguliflorae Compositae and *Centaurea solstitialis*-type seem to be indicative of fluctuating lake levels. On temporarily exposed lake shores these taxa must have expanded considerably. It ought to be mentioned that the group of unidentified Tubuliflorae includes mainly pollen types which could not be further identified because of poor preservation. There are indications that representatives of some other taxa, among others of Chenopodiaceae, may likewise have found suitable habitats on temporarily exposed lake shores. This will come up for discussion at the sites concerned. It will be clear that the decision as to whether or not a pollen type is of predominantly local origin may sometimes be arbitrary. If a pollen type included in the pollen sum has an anomalously high percentage in one or a few samples, this type is left out of the pollen sum in the sample(s) concerned. In the pollen diagram this is indicated by an asterisk.

The main diagram shows the ratio between the percentages for tree pollen (AP) and herbaceous pollen (NAP). In the main diagram the curves for *Pinus*, *Cedrus* or *Quercus* and *Artemisia* are also drawn. On the left of the main diagram the curves for trees and shrubs are represented, on the right those for herbaceous pollen types. On the right of the column with the pollen sums the curves for the pollen types not included in the sum are drawn.

It should be stressed that each diagram has its own pollen assemblage zones. A pollen assemblage zone is characterized by its pollen-floristic composition. At this stage in the investigation it was not felt justified to establish pollen zones of regional character (even if this were feasible).

7.2. *KARAMIK BATAKLIĞI (fig. 12)*

7.2.1. THE GEOGRAPHICAL SITUATION

Karamik Batakliği (vilayet of Afyon) is a depression in a NE-SW orientated basin which is situated to the north of, and possibly partly in, the northwestern offshoots of the Beyşehir/Hoyran *nappes* (Brunn *et al.* 1971). The basin is filled with Neogene and Quaternary sediments. To the north and west of the basin, Neogene deposits and Tertiary volcanic tuffs are exposed, to the south Mesozoic limestone, and to the east Palaeozoic metamorphic rocks, crystalline limestone and dolomite.

At present, Karamik Batakliği, at ca. 1,000 m above sea-level, is largely a marsh with not a great deal of open water. The present-day natural vegetation in the Karamik area is devoid of trees. The vegetation of the slopes has a steppic character, which must be due to the interference of man with the vegetation.

For Afyon, ca. 45 km northwest of the Karamik coring site, at an altitude of 1,018 m, a mean annual precipitation of 478 mm is recorded. Mean January and July temperatures are ca. 0° and 22°C respectively. Relatively much rain falls in the summer (Walter 1955).

The boring (fig. 11) was carried out at the edge of the marsh, 2.5 km southeast of the village of Bulanik (38°25′30″N, 30°48′E). Near the coring locality the following plants were noted: *Phragmites australis*, *Typha angustifolia*, *Eleocharis*, *Ra-*

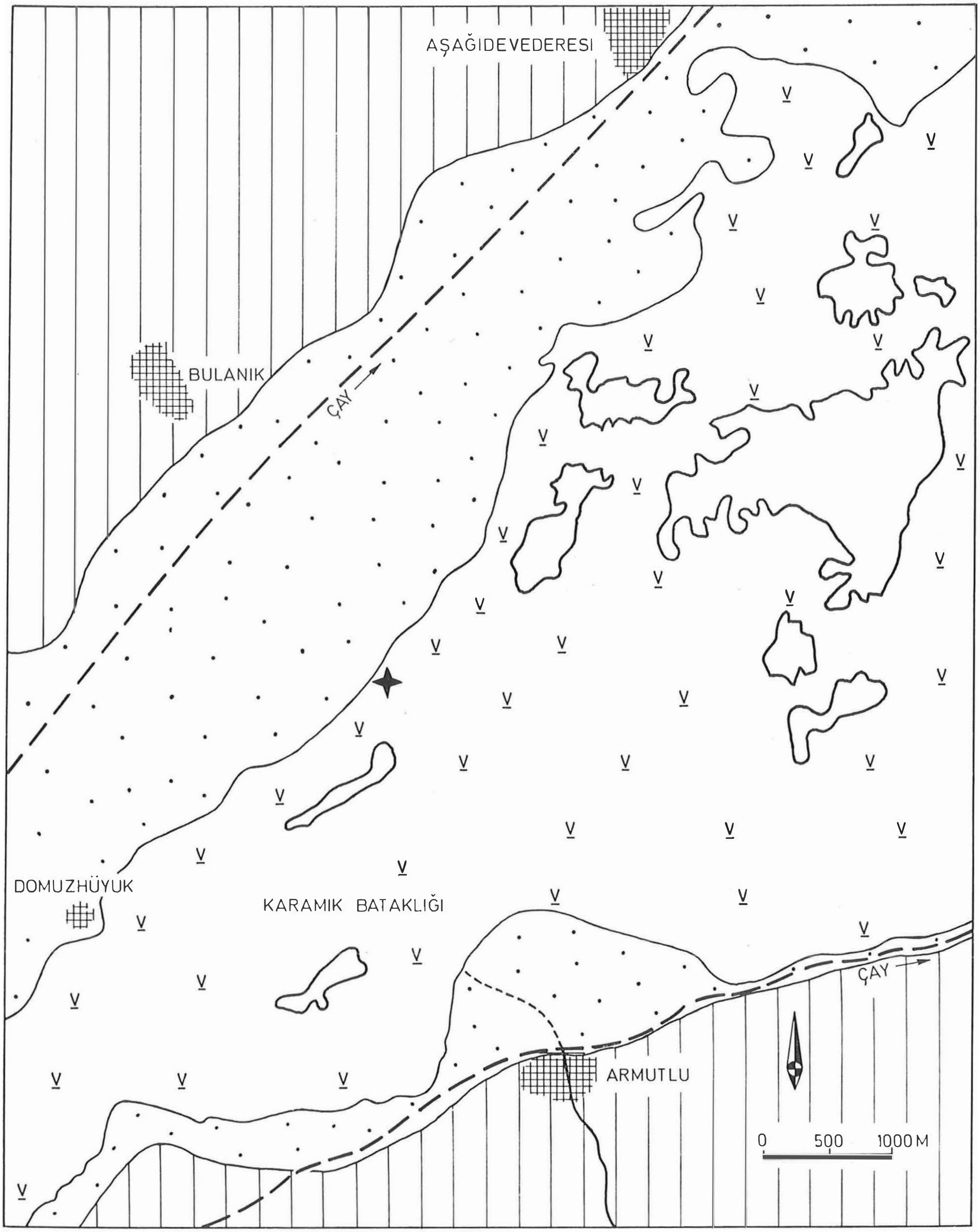


Fig. 11. Location of the coring site of Karamik Batakligi. For explanation of symbols see fig. 13.

nunculus, *Ranunculus* sect. *Batrachium*, *Epilobium*, *Rumex*, *Alisma plantago-aquatica*, *Utricularia*, *Alopecurus*, *Lotus* cf. *uliginosus*, *Juncus*, *Scirpus* cf. *maritimus*, *Poa*, *Butomus umbellatus*.

7.2.2. LITHOLOGY AND RADIOCARBON DATES

The following lithology was recorded:

0 -0.30 m grey clay
0.30-1.15 m yellow-grey clay with red-brown spots
1.15-1.45 m grey clay with red-brown spots and and dark spots
1.45-2.25 m light-grey clay with red-brown spots and dark spots
2.25-2.55 m grey clay with dark spots
2.55-2.85 m light-grey clay with red-brown spots and dark spots
2.85-3.50 m grey clay with red-brown spots and dark spots
3.50-3.95 m dark-grey (organic?) clay
3.95-4.15 m dark-grey clay with red-brown spots
4.15-5.00 m light-grey clay with red-brown spots, black spots and small white particles
5.00-5.05 m sand
5.05-5.20 m light-grey clay with red-brown spots
5.20-5.25 m fine sand
5.25-5.65 m light-grey clay with red-brown spots
5.65-6.05 m green-grey clay

For two levels radiocarbon measurements were carried out:

3.75-4.05 m organic fraction, 6520 ± 70 B.P. (GrN-6880); $\delta C^{13} = -1.9‰$
calcareous fraction (47%), 11,100 ± 140 B.P. (GrN-6890)
5.75-6.05 m organic fraction, 20,130 ± 290 B.P. (GrN-6881); $\delta C^{13} = +2.8‰$
calcareous fraction (39%), 23,320 ± 370 B.P. (GrN-6891)

The actual dating of both sediment sections is provided by the measurements of the organic fraction. Consequently, only these dates will be referred to here.

7.2.3. POLLEN ASSEMBLAGE ZONES 1-4 (SPECTRA 1-24)

In the lower part of the pollen diagram from Karamik Batakliği 4 pollen assemblage zones are distinguished:

zone 1 (spectra 1-4): very high herbaceous pollen percentages;
zone 2 (spectra 5-15): increase in arboreal pollen values;
zone 3 (spectra 16-19): high *Cedrus* percentages;
zone 4 (spectra 20-24): decline in *Cedrus*, increase in herbaceous pollen values.

Assuming a more or less constant sedimentation rate between both radiocarbon dated levels of the Karamik diagram (10 cm in ca. 680 years), which is by no means certain, the following dates can be calculated for these zones:

zone 1 (6.00 -5.67[5] m): 20,800-18,600 B.P.
zone 2 (5.67[5]-5.05 m): 18,600-14,350 B.P.
zone 3 (5.05 -4.65 m): 14,350-11,630 B.P.
zone 4 (4.65 -4.15 m): 11,630- 8,230 B.P.

The much faster sedimentation rate in the upper part of the sediment core (see 7.2.4.) suggests that the upper limit of zone 4 is probably younger than 8,230 B.P. and the same may be true for the zone 3/4 boundary.

Although the pollen assemblage zones 1-4 show fairly considerable differences and consequently reflect different vegetation patterns, for practical reasons they will be discussed together.

7.2.3.1. *The nature of the steppe vegetation*

A first glance at the pollen diagram reveals that its lower part reflects vegetations in which herbaceous species played an important part. Up to spectrum 24 the sum of the non-arboreal pollen values exceeds that of the tree pollen, with the exception of spectra 16-19. The herbaceous pollen percentages are mainly made up by *Artemisia*, Chenopodiaceae and Gramineae, but in addition, a great many other herbaceous pollen types contribute to the group of non-arboreal pollen. These other herbaceous pollen types occur in higher percentages or more frequently in the section covered by zones 1-4 than in the upper part of the diagram. Some pollen types, such as *Helianthemum*, *Hypericum perforatum*-type, *Sanguisorba minor*-type, *Ferula*-type, *Pimpinella*-type, *Scabiosa columbaria*-type and *Allium*-type, are even confined to the lower part of the diagram.

The great variety in herbaceous pollen types suggests that the steppe vegetations were rich in species. In this connection, we should take into consideration the fact that many of the herbaceous pollen types included in the pollen sum originate from insect-pollinated plants. These taxa are under-represented in the pollen rain as compared to wind-pollinated taxa, such as *Artemisia*, Gramineae and Chenopodiaceae. Consequently, the share of these insect-pollinated taxa in the steppe vegetations was probably considerably greater than is suggested by the pollen percentages.

As for the character of the steppe vegetation, the following remarks may be made. As has been discussed above (4.6.), Walter (1956b) is of the opinion that the dominance of *Artemisia* in the present-day steppe vegetations of Central Anatolia is the result of overgrazing; if grazing were suspended, *Artemisia* woud be replaced by grasses. In the time period covered by zones 1 to 4, there would have been no question of overgrazing. Nevertheless, in zones 1 to 3, *Artemisia* usually accounts for about half of the herbaceous pollen values; only in zone 4 is the share of *Artemisia* somewhat lower. This suggests that *Artemisia* was an important constituent of the steppe vegetations concerned, although it shared its role with other species. The Gramineous pollen percentages suggest that members of the grass family were quantitatively important steppe plants, but that, on the other hand, they did not dominate the vegetation. Cerealia-type pollen is fairly common. This pollen type includes various wild grasses (*cf.* 7.3.5.2.).

An evalutation of the possible role of Chenopodiaceae in the upland vegetation is handicapped by the fact that chenopods may have formed part of the local vegetation. As has already been mentioned above (7.1.), Chenopodiaceous species may have expanded on temporarily exposed lake shores. With one exception, the relatively high Chenopodiaceous pollen values in zones 1 to 4 are not accompanied by high percentages for Tubuliflorae and Liguliflorae Compositae and *Centaurea solstitialis*-type, taxa which seem to be indicative of fluctuating lake levels. Only the anomalously high percentages for Chenopodiaceae in spectra 13 and 14 coincide with peaks in the curves for the Compositae pollen types mentioned above. Since Compositae pollen percentages do not point to a considerable expansion of vegetations of intermittently exposed lake shores in any other spectrum in the lower part of the Karamik diagram, one may assume that the majority of the Chenopodiaceous pollen originated from plants from the upland vegetation. Thus, Chenopodiaceae must likewise have played an important part in the steppe vegetations.

In pollen assemblage zones 1, 2 and 3, the *Plantago lanceolata*-type pollen has a continuous curve, with values of up to 2%. Surface-sample spectra from western Iran (Wright *et al.* 1967) show high *Plantago* values for the warm steppe and forest-steppe of the lowland and low foothills, whereas in the spectra from the high plateau steppe in the Tabriz area, at elevations of 1,400 to 2,000 m, plantain is under 5%. The *Plantago* pollen values in the lower part of the Karamik diagram are of the same magnitude as those in the surface-sample spectra from the high plateau of northwestern Iran.

Umbelliferae also played a part in the steppe vegetation reflected in the lower section of the Karamik diagram. However, in the Karamik area, representatives of this family would not have been as abundant as they were in the Lake Zeribar region, in the mountains of western Iran, where Umbelliferous pollen reaches values of more than 30% in the Full-glacial section of the pollen diagram concerned (Van Zeist 1967).

Matricaria-type pollen values are relatively high in zones 1 to 4. This type includes common steppe plant genera such as *Achillea* and *Anthemis.* As has already been discussed (7.1.), species which produce *Centaurea solstitialis*-type pollen probably found suitable habitats on temporarily exposed lake shores. On the other hand, one may assume that *Centaurea* species were likewise constituents of the upland steppe. In summer time the large, purple flower-heads of *Cousinia*, another member of the composite family, may have constituted a prominent feature in the steppe vegetation.

The other herbaceous taxa represented in zones 1-4, which will be mentioned here, are: *Helianthemum* (*H. salicifolium* and *H. ledifolium* are common steppe plants), *Thalictrum* (*Th. minus*), Caryophyllaceae (various genera of this family, such as *Arenaria*, *Dianthus*, *Gypsophila* and *Silene*, occur in steppes), *Limonium*-type (*Plumbago europaea*), *Euphorbia* (*e.g. E. macroclada*), *Thymus*-type (*Thymus squarrosus* is a common steppe plant) and *Sanguisorba minor*. *Ephedra*, a low shrub, must have been rather common in the steppe vegetations of the Karamik area. *Urtica* and *Polygonum aviculare* (and/or close relatives) may have grown particularly near the lake. Both taxa prefer nitrophilous habitats.

7.2.3.2. *The Carya problem*

Although the lower part of the Karamik diagram is characterized by high herbaceous pollen percentages, this by no means implies that the tree pollen types would be of no importance. Not only does *Cedrus* reach high values in pollen zone 3, but also a fairly large number of arboreal taxa is represented in the lower part of the diagram. Before discussing the ecological and quantitative aspects of the tree taxa represented in zones 1 to 4, some attention will first be paid to the presence of *Carya* in the Karamik diagram and in some of the other diagrams included in this study.

At present the genus *Carya* has no representatives in Europe and Southwest Asia. *Carya* species are found in temperate North America, *e.g. C. ovata*, *C. tomentosa* and *C. illinoensis,* where they constituted an important food source for the Indians. The pollen and macrofossil evidence demonstrates that in Late Tertiary and Early Pleistocene times this genus was represented in Europe, and consequently probably also in the Near East. One could wonder whether the almost continuous *Carya* curve in the lower part of the Karamik diagram, with values around 1%, indicates that at that time *Carya* was still present in Turkey. In other words, could *Carya* have persisted in the Near East much longer than has been assumed so far. In this connection the following remarks should be made.

Carya pollen is not only found in the lower part of the Karamik sediment core, but also in the upper part which dates from after 6,500 B.P. Even in the upper sample, from only 1 cm below the surface, a pollen grain of *Carya* was counted. If this pollen had originated from contemporary trees, *Carya* would have grown in Turkey up to recent times. It is inconceivable that in that case there would be no historical records of this useful tree, *e.g.* by Greek or Arab travellers. Remains of hickory nuts have not been recovered from earlier settlement sites either. In the Beyşehir core (7.3.), at a distance of about 110 km from the Karamik site, covering the last 6,500 years, only one *Carya* pollen grain was met with. The near-absence of *Carya* pollen in the Beyşehir diagram and the fact that there are no historical records of this tree suggest that the *Carya* pollen in the Karamik sediment core is of secondary origin. The *Carya* pollen must have originated from Tertiary sediments to the north of the coring site. Among these deposits lignites occur. It is clear that if *Carya* pollen was redeposited, other pollen types may be, partly or completely, of the same secondary origin. Unfortunately, this cannot be proved or shown to be probable. However, in evaluating the Karamik pollen diagram the possibility of redeposited pollen should be taken into consideration.

7.2.3.3. *The trees*

Quercus shows relatively high pollen percentages in zones 1 to 4. No distinction was made between Q. *cerris/infectoria*-type and Q. *calliprinos*-type pollen. The result of a re-examination of a few samples indicates that the large majority of the *Quercus* pollen is of the deciduous oak type. The combination of *Quercus* with high values for herbaceous pollen types points to the presence of oak steppe-forests and forest-steppes. The term "steppe-forest" defines an open forest vegetation (woodland). A "forest-steppe" is a steppic vegetation with sparse tree growth.

Above the belt with oak steppe-forest and/or forest-steppe vegetations, a zone with more or less open coniferous forest stands must have occurred. Besides to *Cedrus*, *Pinus* and *Abies* were found in the coniferous forest zone. The low *Abies* pollen percentages suggest that fir played only a minor part in the coniferous forest vegetations. In evaluating the possible role of fir in the vegetation, it should be taken into consideration that *Abies* is under-represented in the pollen precipitation (6.5.2.). In the period covered by zones 1 to 4, *Juniperus* must have been a scarce tree or shrub in the Karamik area.

Betula is fairly well represented in pollen zones 1 to 4. Nowadays *Betula* constitutes the upper forest zone in the mountains of northeastern Anatolia and on the Erçiyas Dağ in Central Antolia (4.3.). The presence of *Betula* in the Karamik diagram suggests that coniferous forests did not cover the upper part of the Sultandağlari and other mountains in the area. At greater altitudes the cedar-pine-fir forests must have given way to birch stands and perhaps to treeless alpine vegetations. One could wonder whether the Ericaceous pollen, which shows relatively high percentages in the lower part of the diagram, may have originated from the alpine vegetation zone. However, this is not very likely, as at present hardly any Ericaceous species are found in the high mountains of Anatolia. Most probably the Ericaceous pollen is of secondary origin.

Hippophaë shows relatively high values in zones 1 and 2. *Hippophaë*, which occurs as a shrub and as a small tree, has a very wide distribution in Europe and Asia (Hegi 1926, pp. 732-741). Moreover, it is found from sea-level up to high in the mountains. Thus, this species is reported for elevations of up to 3,000 m in the mountains of Afghanistan (Murray 1968). Its occurrence in southern Siberia proves that *Hippophaë* can endure extreme continental conditions. Consequently, its former occurrence in the Karamik area under relatively cold and dry conditions (see below) is not astonishing.

As for the other trees represented in the lower part of the Karamik diagram, *Alnus* and *Ulmus* may have found suitable habitats alongside streams and in other places with a high groundwater table. For various other trees it is unlikely that at that time they could be found in the Karamik area. The pollen of *Tilia*, *Fagus*, *Corylus* and *Picea* is probably due to redeposition, although some long-distance transport, particularly from the Black Sea area, is also possible.

7.2.3.4. *The local vegetation*

Marsh and water plants are rather scarcely represented in zones 1 to 3 (spectra 1-19). This probably indicates that the sediment was deposited in rather deep water. The conspicuous maximum in the curves for *Centaurea solstitialis*-type and Liguliflorae Compositae in spectra 13 and 14 is probably indicative of fluctuating lake levels during the period concerned.

In zone 4 (spectra 20-24) *Sparganium*-type pollen percentages are rather high, Cyperaceae show a maximum at the base of the zone, while *Typha latifolia* has a peak at the end of the zone. During zone 4 time, marsh vegetations must have been found near the coring locality. The presence of *Myriophyllum* pollen in zone 4 suggests that at the coring site itself open water prevailed. Moreover, the fact that no peat was deposited indicates that the marsh vegetation belt had not reached the locality where the boring was carried out. An expansion of marsh vegetations or an inward shift of the marsh vegetation belt must have been due either to a general lowering of the lake level or to an infill with sediment. In both cases the water would have become shallow in places where formerly it was much deeper.

7.2.3.5. *Vegetation pattern and climate*

Finally, a few speculations will be made on vegetation pattern and climate during zones 1 to 4. Zone 1 (calculated age 20,800-18,600 B.P.) is characterized by very high herbaceous pollen percentages, *Artemisia* showing values between 42 and 56‰. During this period, steppe vegetations prevailed in the Karamik area. In the mountains, scattered stands of *Quercus*, *Abies*, *Pinus* and *Cedrus*, either mixed or pure, were probably found in suitable habitats. The predominantly steppe vegetations of zone 1 indicate that at the time it was a dry climate. As for the temperature, the inferred dating of this zone suggests that it must also have been much colder than at present. It should be stressed here that the pollen record does not provide much information on the temperature. The fairly low *Plantago* pollen percentages suggest only that the steppe reflected in zone 1 was not a warm lowland steppe (7.2.3.1.). However, whether the then-existing vegetation was of the type of the present-day Central Anatolian steppe or of the much colder East Anatolian plateau steppe cannot be ascertained.

The transition to pollen zone 2 (ca. 18,600-14,350 B.P.) is marked by an increase in *Cedrus* as well as in *Quercus*. Both trees could expand, probably as a result of a somewhat moister climate; oak at lower elevations and cedar higher up in the mountains. It is striking that the increase in pine in the upper part of zone 2 is accompanied by a decrease in *Quercus*. One might wonder whether this indicates that in the upper reaches of the steppe-forest, oak was replaced by pine. *Pinus* can also be a constituent of steppe-forest vegetations (Pinion nigrae xero-euxinum; Zohary 1973, pp. 580-581). In this connection it may be of significance that the *Quercus* maximum in spectrum 14 coincides with a decline in *Pinus*.

During zone 3 time (ca. 14,350-11,630 B.P.), cedar increased considerably. The decrease in *Pinus* and *Quercus* may indicate that cedar encroached upon the area formerly occupied by steppe-forest. During this period steppic vegetations could maintain themselves in the Karamik region, although their acreage had shrunk quite notably. The expansion of the cedar forest suggests that the humidity had increased markedly since the beginning of zone 2. It is likely that the temperature had also risen.

Zone 4 (ca. 11,630-8,230 B.P.) reflects a strong decline in cedar and an expansion of open vegetations. The vegetation pattern may have been similar to that of the upper part of zone 2. In zone 4 time, the early-Postglacial increase in temperature must have taken place. One wonders to what extent the drier climate of this zone (which is suggested by the increased herbaceous pollen values) was the result of this rise in temperature.

7.2.4. POLLEN ASSEMBLAGE ZONE 5 (SPECTRA 25-29)

Pollen zone 5 shows a strong decline in herbaceous values and an increase in coniferous percentages. This zone constitutes the transition from the more or less open vegetation pattern reflected in zones 1-4 to the continuous forest cover of zone 6 (7.2.5.). At the end of zone 5 the *Artemisia* pollen values have dropped to under 1%.

Puzzling is the alternation of dominant pollen values for cedar and pine. This phenomenon is also observed in zones 6 and 7 and will be discussed below (7.2.5.). During zone 5 time, coniferous forests expanded over areas formerly occupied by steppe and forest-steppe. If treeless alpine vegetations existed in the Karamik area in the previous periods, they would also have been replaced by coniferous forest in zone 5 time. At the end of this period temperature and humidity must approximately have reached modern levels.

Spectrum 27 shows a maximum in the ΣNAP which is mainly due to higher values for *Artemisia* and Chenopodiaceae. As for the peak in the chenopod curve, one should take into consideration that Liguliflorae and Tubuliflorae Compositae and *Centaurea solstitialis*-type show high values in spectrum 27. Consequently, the Chenopodiaceae maximum could have been the result of a local expansion of one or more chenopod species on the intermittently exposed lake shore. However, the temporary increase of the perennial *Artemisia* is difficult to explain in this way. Is the low *Artemisia* maximum perhaps an indication of a temporary return to more arid conditions? The slightly higher *Quercus* pollen percentages in spectra 27-29, suggesting that oak forest-steppe was found again in the Karamik area, could point in the same direction. On the other hand, it is also possible that the increase in *Artemisia* was due to the interference of man with the vegetation. For Beyşehir, at ca. 110 km from the Karamik coring site, it could be demonstrated that *Artemisia* expanded considerably as a result of large-scale forest clearing and subsequent land use (7.3.5.2.). Oak profited also from the activity of man in the Beyşehir area. It should, however, be stressed that other possible palynological indications of the influence of prehistoric man are absent in the upper part of zone 5 at Karamik. For that reason, it cannot be decided whether the expansion of *Artemisia* suggested by spectrum 27 was brought about by climate or by man.

In connection with the dating of this period the following remarks should be made. For the dating of the boundaries between zones 5 and 6 and 6 and 7 a constant sedimentation rate between the radiocarbon dated level at 3.75-4.05 m and the top of the sediment has been assumed. For the interpolation it has further been assumed that the surface of the sediment corresponds with the present time, which may not be entirely justified. This gives a sedimentation rate of 10 cm in ca. 167 years. For the zone 5/6 boundary an age of 5,850 B.P. is calculated in this way. For the lower boundary of zone 5 a calculated age of 8,230 B.P. was obtained (see 7.2.3.), but this date is probably somewhat too old. The *Artemisia* maximum in spectrum 27 should be dated to ca. 6,300 B.P.

7.2.5. POLLEN ASSEMBLAGE ZONE 6 (SPECTRA 30-44)

Pollen zone 6 is characterized by high tree pollen values. With one exception, *Artemisia* percentages are very low. The fairly high Chenopodiaceae pollen values in spectra 35-39 coincide with high percentages for *Centaurea solstitialis*-type and for Tubuliflorae and Liguliflorae Compositae. Consequently, the majority of the chenopod pollen in this section is very likely of local origin. Zone 6 represents a period during which the Karamik area was wholly covered by forest, in which *Pinus* and *Cedrus* played alternately a predominant part, whereas *Abies* was of minor importance. *Quercus* was perhaps mostly represented as shrub in the coniferous forest.

A striking feature of pollen assemblage zone 6, and also of zones 5 and 7, is the alternation in the dominance of *Pinus* and *Cedrus* percentages. Changes in the proportions of both trees in the forest of the Karamik area must sometimes have been quite rapid. The *Pinus* maximum in spectrum 33, at 3.00 m, is succeeded by a *Cedrus* maximum in spectrum 35, at 2.80 m, implying that in about 350 years (10 cm = ca. 167 years) pine had to a considerable extent been replaced by cedar. In other cases a similar change apparently took more time. Thus, ca. 1,000 years elapsed until the *Cedrus* dominance of spectrum 41 had been succeeded by the *Pinus* dominance of spectrum 44. As for the evaluation of the pine and cedar pollen percentages, both trees have a good pollen production and dispersal, but compared with *Pinus*, *Cedrus* is under-represented in the pollen precipitation. This implies that the proportion of *Cedrus* in the coniferous forest vegetations of the Karamik area was greater than the cedar-pine ratio in the pollen precipitation.

It is not likely that the alternating predominance of pine and cedar resulted from the interference of man with the vegetation; at least, indications of human activity are scarce or absent in zone 6. Neither is it probable that this alternation constituted a kind of natural succession cycle, as otherwise similar fluctuations in pine and cedar percentages might also be expected in the diagrams prepared from the Beyşehir and Hoyran cores, at distances of 110 and 20 km respectively from the Karamik site (7.3. and 7.4.). There seems to be no alternative to assuming that this phenomenon was caused by climatic fluctuations, although the same objections can be raised to this hypothesis as to the assumption of a natural succession cycle. One wonders whether the climatic conditions in the Karamik area were such that even a minor change in humidity effected a marked shift in the pine-cedar ratio.

Betula shows slightly higher pollen percentages in spectra 42, 43 and 44. It has already been mentioned (4.3.) that birch is found in the mountains of northeastern Anatolia and on the Erçiyas Dağ in Central Anatolia, but that at present this tree does not occur in southwestern Turkey. It is possible that the *Betula* pollen in zone 6 is of secondary origin (7.2.3.2.). On the other hand, the pollen evidence for Beyşehir (7.3.5.4.) and Söğüt (7.5.9.) suggests that birch may still have occurred in southwestern Turkey in Postglacial times.

It is striking that the minor *Artemisia* maximum in spectrum 34 is, again, accompanied by a small *Quercus* peak (*cf.* zone 5, spectra 27-29).

The percentages for Tubuliflorae and Liguliflorae Compositae and *Centaurea solstitialis*-type suggest lake-level fluctuations during the greater part of zone 6. The fairly high percentages for Cyperaceae and *Sparganium*-type in spectrum 39 indicate that at that time marsh vegetations were found in the vicinity of the coring locality.

The zone 6/7 contact at 0.90 m has a calculated date of 1,500 B.P., implying that zone 6 lasted from ca. 5,850 to 1,500 years ago.

7.2.6. POLLEN ASSEMBLAGE ZONE 7 (SPECTRA 45-50)

Herbaceous pollen types, such as Chenopodiaceae, *Artemisia*, Gramineae, Cerealia-type, *Plantago lanceolata*-type, *Delphinium*-type, Caryophyllaceae, Umbelliferae, *Brassicia*-type and *Senecio*-type, increase in this zone. The rather high values for Cerealia-type pollen do not necessarily point to grain-growing, as various wild grasses produce pollen of this type (7.3.5.2.). A better indication of human activity is perhaps provided by the *Plantago lanceolata*-type pollen in the upper four spectra, which may point to grazing.

As for the high Chenopodiaceous pollen percentages in zone 7, Tubuliflorae and Liguliflorae

Compositae and *Centaurea solstitialis*-type show similar rather high values in this zone. For that reason, it is likely that most of the Chenopodiaceous pollen is of local origin. One cannot exclude the possibility that the increase in Gramineae and Cerealia-type at the base of the zone was largely or entirely brought about by a local expansion of grasses on the temporarily exposed lake shore. On the other hand, the upper part of the zone most probably reflects the interference of man with the upland vegetation.

Alnus and *Salix* are likely to have found suitable habitats alongside streams or on the banks of the lake itself. As for the slightly higher *Corylus* percentages in zone 7, the diagrams from Beyşehir and Söğüt provide evidence of a minor expansion of this shrub as a result of forest clearing (7.3.5.4. and 7.5.9.). *Corylus* could have profited from the deforestation in the Karamik area also. However, it is also possible that the *Corylus* pollen in the upper part of the Karamik diagram is of secondary origin (*cf.* 7.2.3.2.).

Finally, attention should be drawn to the fact that in the uppermost sample, at a depth of only 1 cm, the total tree pollen percentage is fairly high. Trees must still have played an important part in the Karamik area at the time of deposition of the sediment at 1 cm below the surface. At present the area is devoid of trees. Consequently, either the last few hunderd years are not represented in the sediment core or the complete deforestation is of very recent date (see also Söğüt, 7.5.10.).

7.3. *BEYŞEHIR GÖLÜ (fig. 14)*

7.3.1. THE GEOGRAPHICAL SITUATION

Beyşehir Gölü (vilayets of Konya and Isparta), at an altitude of ca. 1,120 m, is located in the central part of the eastern limb of the "Courbure d'Isparta" (*cf.* 2.1.2.). In this limb was formed a NW-SE orientated, long (at least 150 km) but narrow (15-20 km) zone of *nappes* (overthrusted folds), localized along the axis of a major syncline in the underlying limestone. Thus, the lake is of structural origin. To the east and north of the lake, Neogene sediments are exposed over large areas. To the west of the lake, the Anamas mountains, consisting mainly of limestone, reach elevations of nearly 3,000 m.

To the southwest of the lake, a marshy, south-north orientated valley with a few meandering rivulets is present (fig. 13). The valley is filled with Quaternary sediments. Upstream the rivulets do not cut through Neogene sediments, so that it is not likely that they brought down Tertiary pollen. The boring was carried out in the northern part of the valley, at a distance of ca. 2 km east of Yesildağ (37°32′30″N, 31°30′00″E). In consequence of the braided river system in the valley, gaps in the local sedimentation may be expected. In the Beyşehir core no obvious indications of a hiatus are present.

The mean annual precipitation at Beyşehir, ca. 25 km east-northeast of the coring site, is 499 mm. The mean January temperature is just below 0°C, and the mean August temperature ca. 22°C. The summer (June, July, August) is a decidedly dry period with hardly any rain (Walter 1955).

7.3.2. LITHOLOGY AND RADIOCARBON DATES

The following lithology was recorded:

0 -0.65 m	yellow-grey clay with red-brown (oxidation) spots
0.65-1.05 m	blue-grey clay with red-brown (oxidation) spots
1.05-1.25 m	grey clay with red-brown (oxidation) spots
1.25-1.65 m	yellow-grey clay with red-brown (oxidation) spots
1.65-2.65 m	blue-grey clay with red-brown (oxidation) spots
2.65-5.45 m	blue-grey clay with some fine gravel between 4.85 and 4.90 m

For two levels radiocarbon measurements were carried out:

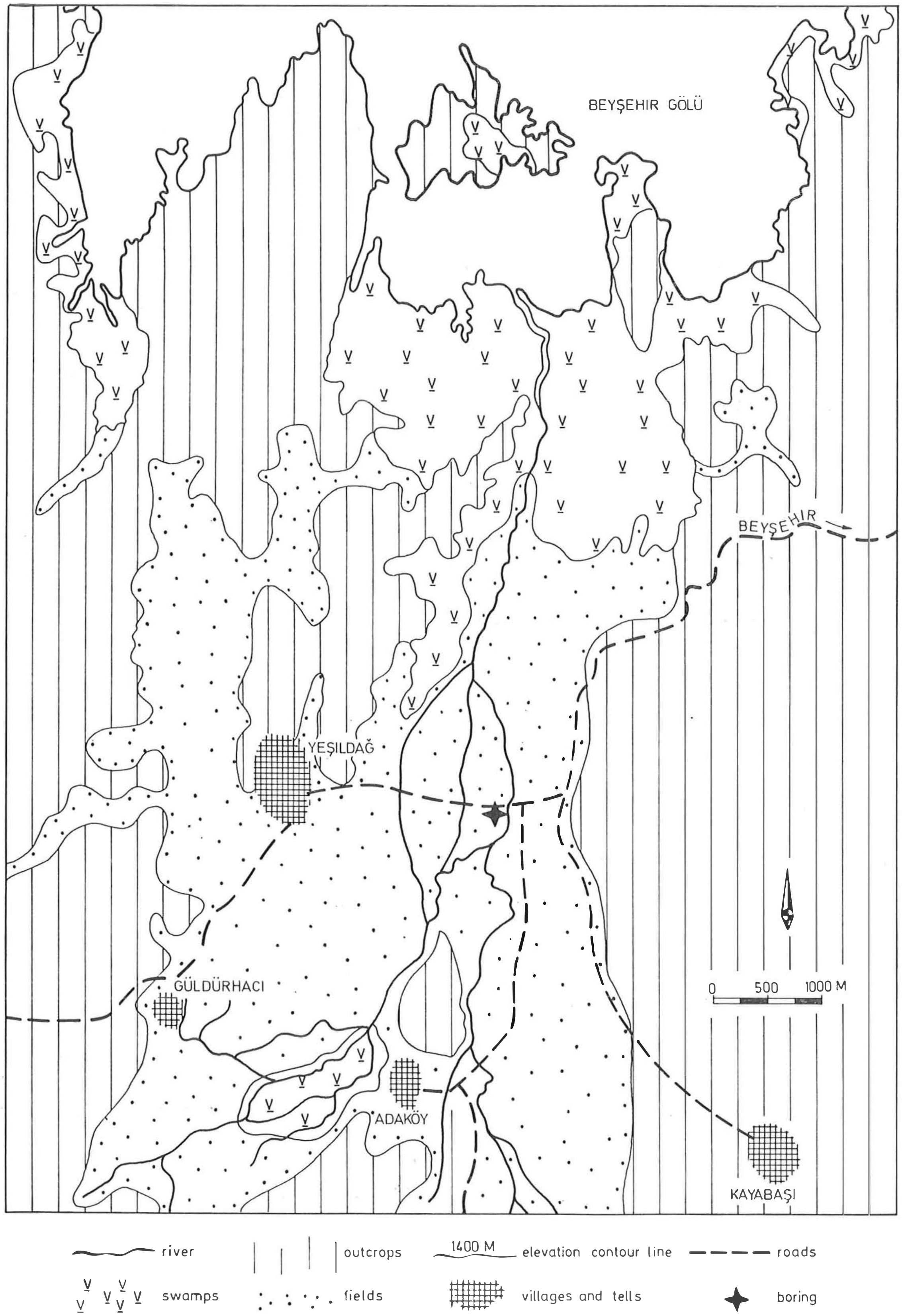
2.65-2.85 m, 3,265 ± 35 B.P. (GrN 6879)
4.95-5.25 m, 6,090 ± 75 B.P. (GrN 6878)

The organic fractions were measured. The carbonate content of the lower sample was 4%, that of the upper sample 10%.

7.3.3. POLLEN ASSEMBLAGE ZONE 1 (SPECTRA 1-3)

This zone is characterized by high *Cedrus* pollen

Fig. 13. Location of the Beyşehir coring site.


BEYŞEHIR GÖLÜ
BEYŞEHIR
YEŞILDAĞ
GÜLDÜRHACI
ADAKÖY
KAYABAŞI
0 500 1000 M
river
outcrops
1400 M
elevation contour line
roads
swamps
fields
villages and tells
boring

values with *Pinus* in the second place. Of the other trees represented in the Beyşehir diagram, only *Quercus* has slightly higher percentages in this section. Upland herbs show low pollen percentages in zone 1.

The pollen evidence indicates that during zone 1 time, coniferous forest with predominantly *Cedrus* covered the uplands to the south and west of Beyşehir Gölü. The results of the surface-sample study suggest that the proportion of pine in the forests in the Beyşehir area was smaller than indicated by its pollen percentages. During this period *Abies* was not found in the Beyşehir area, not even at a greater distance from the coring site; fir pollen is completely absent in the lowermost spectra. Deciduous oak trees were probably present, although in small numbers. Further, oak shrub should have occurred in the undergrowth of the coniferous forest.

The high *Sparganium*-type values and the fairly high *Dryopteris* percentages point to marsh vegetations at a short distance from the coring site during zone 1 time.

The calculated date of ca. 5,850 B.P. for the zone 1/2 boundary is based upon an average sedimentation rate of 10 cm per 120 years, which can be deduced from both radiocarbon dates obtained for the Beyşehir core (7.3.2.).

7.3.4. POLLEN ASSEMBLAGE ZONE 2 (SPECTRA 4-15)

This zone, which is also characterized by high coniferous pollen values and generally low herbaceous percentages, is subdivided into three subzones.

Subzone 2a (*spectra 4*-7). At the transition from zones 1 to 2 *Cedrus* to a large extent gave way to *Pinus*; pine became the quantitatively most important tree in the upland forests of the area. In the upper part of subzone 2a, the continuous *Abies* curve starts, with pollen values of over 0.5%, indicating that fir became a constituent of the coniferous forest, although probably not in the immediate vicinity of the Beyşehir coring site. The very poor representation of *Quercus* suggests that oak played an insignificant part in the vegetation; this species probably occurred only in the undergrowth of the coniferous forest. The slightly higher *Corylus* percentage in spectrum 5 is not accompanied by an increased NAP value, so that a possible (local) expansion of hazel was not induced by an opening up of the forest. *Alnus* could have grown alongside the water.

Subzone 2b (spectra 8-10). In this subzone *Pinus* pollen values show a slight drop, whereas *Quercus*, *Artemisia*, Gramineae and Chenopodiaceae have somewhat higher values. This subzone, which probably represents a period of interference of man with the vegetation, will be discussed later (7.3.5.7.).

Subzone 2c (spectra 11-15). This subzone is nearly identical with subzone 2a. Only the *Cedrus* pollen values are lower, indicating that the role of cedar had diminished further.

From the high percentages for *Dryopteris* and *Botrychium*-type in spectra 4, 5 and 6 one must conclude that at that time a marsh vegetation of predominantly ferns was found at a short distance from the coring site. The greater part of pollen zone 2 shows fairly high percentages for Tubuliflorae and Liguliflorae Compositae and *Centaurea solstitialis*-type, indicating fluctuations of the lake level. One wonders whether the relatively large numbers of *Polygonum aviculare*-type pollen also originate from a *Polygonum* species which expanded on intermittently exposed lake shores. The high Cyperaceous percentage in the uppermost spectrum of this zone points to the presence of a marsh vegetation, but this time of a different type than that reflected in spectra 4-6.

The zone 2/3 contact at 2.97^5 m has a calculated date of 3,535 B.P., so that zone 2 lasted from ca. 5,850 to 3,535 B.P.

7.3.5. POLLEN ASSEMBLAGE ZONE 3 (SPECTRA 16-31)

7.3.5.1. *Introduction*

Pollen zone 3 is subdivided into 5 subzones. Before discussing the particulars of each subzone (7.3.5.5.) we will deal with some general features of zone 3.

The lower part of zone 3 reflects drastic changes in the vegetation of the Beyşehir area. *Pinus* shows a marked decline, whereas the percentages for herbaceous pollen types, such as *Artemisia*, Chenopodiaceae, Gramineae and *Plantago lanceolata*-type, increase. However, not only the herbs but also the deciduous trees achieve higher pollen values. In particular *Fraxinus ornus* and *Quercus* show a distinct rise. In addition, *Juglans*, *Castanea* and *Sambucus* appear.

The greater part of zone 3 is characterized by comparatively low *Pinus* and high herbaceous pollen values. Moreover, various deciduous trees and shrubs and *Juniperus* are represented by higher percentages. Above spectrum 27 *Pinus* values increase again, whereas the herbs and the deciduous tree pollen types decrease. *Abies* shows a recovery as well.

The course of the pollen curves in zone 3 is undoubtedly a reflection of the interference of man with the vegetation near the south side of Beyşehir Gölü. The strong decline in the coniferous pollen percentages indicates that during zone 3 time large areas were stripped of the natural forest cover.

In pollen zone 3, Cyperaceae and *Sparganium*-type values are usually fairly high, suggesting that marsh vegetations prevailed in the vicinity of the coring site.

7.3.5.2. *The herbs*

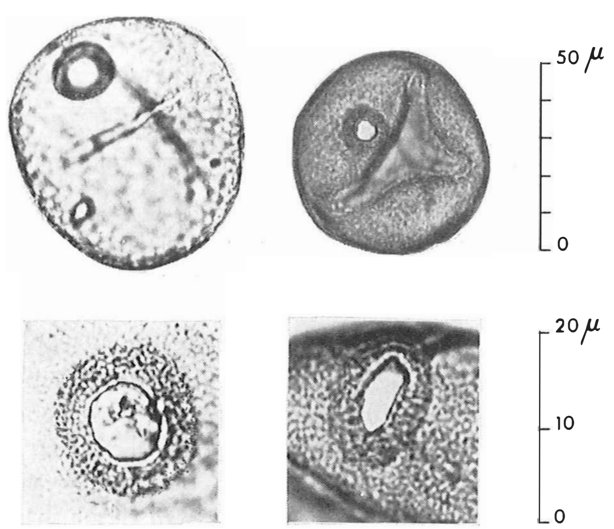
The forest clearings favoured the expansion of herbaceous taxa, such as *Artemisia*, Chenopodiaceae and Gramineae. *Plantago lanceolata*-type pollen reaches similar high percentages in zone 3. It is probable that the increase in *Plantago* was not only induced by the forest clearings, but that it was also caused by the subsequent grazing in the deforested areas. The surface-sample study has demonstrated that apparently grazing does not necessarily lead to an expansion of *Plantago* species, but higher plantain pollen values were always obtained for areas with serious grazing.

As for palynological indications of crop plant growing, Cerealia-type pollen shows relatively high percentages in zone 3. In the Near East, unfortunately, Cerealia-type pollen is less indicative of farming than it is in Central, West and Northwest Europe. Various wild grass species in the Near East produce pollen grains of the Cerealia-type. Characteristic features of Cerealia-type pollen (fig. 15) are the size (at least 40μ in silicone oil mounted slides), the thick wall and the pronounced annulus (ring around the pore). The Near Eastern wild grass species with Cerealia-type pollen, represented in the pollen reference collection in the Biologisch-Archaeologisch Instituut, include: *Aegilops kotschyi*, *Aegilops triuncialis*, *Agropyron intermedium*, *Agropyron pectiniforme*, *Bromus tomentellus*, *Eremopyrum bonaepartis*, *Heteranthelium piliferum*, *Hordeum fragile* and *Stipa lagascae.* It should be stressed that not all the species mentioned above produce exclusively Cerealia-type pollen.

Barley and wheat, the most important cereal crop plant species in the Near East from the early-Neolithic up to the present time, are self-pollinators which release only few pollen grains. As a result, these species are seriously under-represented in the pollen precipitation and subsequently in the fossil pollen record. On the other hand, many wild grasses, including those with Cerealia-type pollen, are wind-pollinators and may have contributed essentially to the pollen rain.

From the above one must conclude that the higher Cerealia-type pollen values in zone 3 of the Beyşehir diagram do not necessarily point to grain-growing, although it is very likely that cereal species and other crop plants were cultivated by the people whose activities are reflected in pollen zone 3. The other potential crop plants, such as *Lens culinaris* (lentil), *Pisum sativum* (pea), *Vicia ervilia* (bitter vetch) and *Linum usitatissimum* (linseed), are insect-pollinators and are for that reason scarcely represented in the pollen precipitation.

Fig. 15. Cerealia-type pollen grains. To the left: *Aegilops kotschyi*; to the right: *Triticum aestivum*.



7.3.5.3. *Cultivated trees*

The Beyşehir farmers planted *Juglans* (walnut) and *Castanea* (sweet chestnut). The absence of pollen of these species below spectrum 15 at least suggests that these trees dit not formerly grow in the area. *Olea*, which is represented in zone 3 by fairly low percentages, was probably also cultivated. It is not likely that olives belonged to the natural vegetation of the Beyşehir area. Although it cannot be excluded that wild grapes occurred in the area, the presence of *Vitis* pollen in some spectra of zone 3 suggests that this species was cultivated.

Very striking are the high *Fraxinus ornus* pollen values. Manna ash occurs in the Oro-Mediterranean forest vegetations, but it is never a quantitatively important constituent, at least not in southwestern Turkey. Neither has it been observed that this tree expanded in or along forest clearings. In the surface-sample spectra from southwestern Turkey, *Fraxinus ornus* is represented irregularly and, with one exception, in low frequencies. In view of its high pollen values in the Beyşehir diagram, one could wonder whether *Fraxinus ornus* was planted. In this connection the following should be mentioned. From this tree a sweetish exudate called manna can be obtained by making incisions in the bark. The exudate appears also after injuries made by cicades. The dried up exudate of the manna ash is used as food as well as for medicinal purposes (Von Wiesner 1928, p. 2063). At present this tree is cultivated in Sicily and Calabria for its manna (Polunin & Huxley 1970, p. 144). The pollen evidence from Beyşehir, and also from Söğüt (7.5.9.), seems to indicate that in southwestern Turkey manna ash was cultivated in the second and first millennia B.C.

7.3.5.4. *Wild trees*

From the diagram it is obvious that particularly *Quercus* profited from the clearing activities. Originally, no distinction was made between the deciduous oak pollen type and the *Quercus calliprinos* pollen type. Later, when more samples were examined in the section covering pollen assemblage zone 3, both types were distinguished. In the spectra concerned the share of *Quercus calliprinos*-type pollen is indicated by a white bar. It is clear that Q. *calliprinos* was of minor importance in the Beyşehir area during zone 3 time. This is in accordance with the fact that in surface sample 56, near the south side of Beyşehir Gölü, only 5 Q. *calliprinos*-type pollen grains were counted, as against 76 of the deciduous oak type. Moreover, Q. *calliprinos* was not observed by the authors in the area south of Beyşehir Gölü.

Oak could expand along forest edges and on abandoned fields. It is likely that oak was already present in the area as undergrowth in the coniferous forests. Thus, in the present-day *Pinus nigra* forests in the mountains to the south of Beyşehir Gölü, *Quercus cerris* is a common shrub. After the cutting of pine and cedar, the oak shrub got a chance to grow out. The near-absence of *Quercus* pollen in zone 2 does not necessarily contradict the assumption that oak persisted in the area. In this connection one should take into consideration that oak shrub does not flower abundantly and that, moreover, the pollen does not easily get out of the forest.

Juniperus pollen percentages remain relatively low in zone 3, suggesting that juniper did not expand greatly in the cleared areas. At present, *Juniperus* is a common shrub on grazed terrains in southwestern Turkey. It often forms the last reminiscence of the original forest cover.

Corylus and *Sambucus*, both of which may have occurred as shrub in the conifer forests, probably found suitable habitats along forest edges. It should be emphasized that *Corylus* did not become a common shrub; otherwise this species, which has a good pollen production and dispersal, should have shown considerably higher pollen frequencies.

The course of the *Ostrya/Carpinus orientalis* curve suggests that either *Ostrya carpinifolia* or *Carpinus orientalis* expanded to some extent as a result of the forest clearings. It was, in all probability, *Carpinus orientalis*. Zohary (1973, p. 365) reports that this species occurs in several open plant communities, sometimes in the form of stunted shrub.

Another tree which apparently profited from the clearing activities is *Betula*. This is somewhat strange because at present birch is not found in the Beyşehir area. As has already been discussed (4.3.), *Betula* occurs in the mountains of eastern Anatolia on the Erçiyas Dağ in Central Anatolia.

One might wonder whether ca. 3,000 years ago the natural distribution area of *Betula* still included southwestern Turkey, in consequence of which birch could more easily reach cleared areas at lower elevations than would have been possible at present. However, it remains to be explained why *Betula* could not maintain itself in disturbed areas.

7.3.5.5. *The subzones*

In *subzone 3a* (spectra 16-18), the *Pinus* curve shows a rapid decline, while *Cedrus* decreases likewise. Over large areas the forest must have been cut, but *Abies* was not yet affected by the clearing activities. *Fraxinus ornus*, *Juglans* and *Castanea* are represented, indicating that these trees were planted by the people who lived near the southwest side of Beyşehir Gölü. *Quercus* and *Juniperus* could expand on the open terrain. The increase in *Plantago lanceolata*-type pollen probably indicates grazing.

A conspicuous feature of subzone 3a are the high *Salix* pollen percentages which are not included in the pollen sum. This strong expansion of willow points to the presence of rather extensive marsh lands, where this tree found suitable habitats. One wonders whether these marsh lands came into existence as a result of a rapid filling up of shallow parts of the lake. In this connection it should be mentioned that the large-scale deforestation probably caused a strongly increased erosion. The high Umbelliferous percentages and the maxima in various other herbaceous pollen curves suggest a local expansion of the taxa concerned.

Subzone 3b, represented by only one spectrum, seems to reflect a partial recovery of *Pinus*. It is striking that *Plantago lanceolata*-type pollen was not found in spectrum 19, which suggests that grazing had stopped or at least had diminished considerably. The fact that the pollen curves for *Fraxinus ornus*, *Juglans* and *Castanea* do not decrease (or hardly at all) would plead against a temporary abandoning of the area by man. On the other hand, this phase may have lasted for as short a time as ca. 60 years (see 7.3.5.6.), during which period these trees may have maintained themselves without human care.

In *subzone 3c* time (spectra 20-24), again large areas must have been cleared. *Cedrus*, the pollen values of which show a steady decline from spectrum 15 on, has low percentages in subzone 3c. Now, the cutting affected *Abies* likewise. *Fraxinus ornus*, *Quercus*, *Juniperus*, *Artemisia* and *Plantago lanceolata*-type reach relatively high pollen percentages. It is in this subzone that *Sanguisorba minor*-type pollen is fairly frequent (*cf.* 7.5.9.). This subzone reflects extensive forest clearings as well as farming activities on a considerable scale.

Subzone 3d (spectra 25-27) suggests another wave of forest cutting. *Pinus* pollen values drop to as low as ca. 8%. The surface-sample study has demonstrated that *Pinus* pollen values may be quite high, although pine is not present (or hardly at all) in the area of the sampling site. Thus, the surface sample taken south of Beyşehir Gölü (sample 56) yielded 43% *Pinus* pollen, although pine is found only at some distance from the site. Consequently, *Pinus* pollen values of 10 to 20% in spectra 25 to 27 suggest that near the coring site virtually nothing was left of the original forest.

Subzone 3e (spectra 28-31) reflects the regeneration of the forest. The pollen percentages of herbs as well as of deciduous trees decrease markedly, whereas those of *Pinus* and *Abies* increase. The coniferous forest took again possession of the area, but cedar failed to recover. Whether the presence of *Fraxinus ornus* and *Juglans* in this subzone indicates that these trees were still grown, be it on a much smaller scale, or whether they could only maintain themselves to some extent, cannot be established. The same applies to *Plantago lanceolata*-type with respect to grazing. Consequently, it cannot be ascertained whether the area was abandoned by man abruptly or more gradually.

It is doubtful whether in order to obtain arable land and grazing terrain of sufficient size the forest clearings had to be so extensive as is suggested by the pollen record. It is attractive to suppose that the forests were primarily cleared because of the timber, that was transported to the larger population centres of those days, where it was much in demand for construction purposes.

7.3.5.6. *The dating*

It has already been mentioned that from both radiocarbon dates for the Beyşehir core (7.3.2.) an average sedimentation rate of 10 cm per 120 years may be deduced for the section between 5.10 and 2.75 m. For the section above 2.75 m the average sedimentation rate is the same, *viz.* 10 cm per 119 years, assuming that the surface of the sediment corresponds with the present time.

The inferred date for the zone 2/3 boundary is 3,535 B.P. (7.3.4.) and for the zone 3/4 contact, at 1.32^5 m, 1,555 B.P. For the subzones the following dates are calculated:

Subzone 3a, 2.97^5-2.82^5 m: 3,535-3,355 B.P. (180 years).

Subzone 3b. The upper border of subzone 3b is uncertain. Between samples 19 and 20 no intermediate samples could be examined as this section of the core had been used up for the radiocarbon measurement. It is possible that already at a depth of 2.70 or 2.75 m *Pinus* pollen percentages are again low, so that the 3b/3c boundary should be laid at 2.77^5 or 2.75 m instead of at 2.70 m. Consequently, the end of subzone 3b has a minimum date of 3,295 B.P. and a maximum date of 3,115 B.P. (2.62^5 m), implying a minimum and maximum duration of this subzone of 60 and 240 years respectively (see discussion of subzone 3b in 7.3.5.5.).

Subzone 3c lasted from ca. 3,205 (3,295-3,115) B.P. to 2,545 B.P. (2.15 m), that is ca. 660 years.

Subzone 3d, 2.15-1.85 m: 2,545-2,185 B.P. (360 years).

Subzone 3e, 1.85-1.32^5 m: 2,185-1,550 B.P. (630 years).

Thus, the period of extensive human activity (with one interuption in subzone 3b) lasted from 3,535 to 2,185 B.P., that is ca. 1,350 years. The regeneration of the forest, which may have been retarded by the continued presence of man, lasted for more than 600 years.

7.3.5.7. *Subzone 2b (spectra 8-10)*

In comparing subzone 2b with zone 3 it becomes likely that the former reflects a forest clearance at a much more modest scale than that of zone 3. As a result of the forest clearing, oak could expand along with various herbs (*Artemisia*, Chenopodiaceae, Gramineae). *Plantago lanceolata*-type pollen was only found in sample 9. The decrease in *Cedrus* pollen values takes place above subzone 2b, so that in this case the decline was not the direct or indirect result of the activity of man.

7.3.6. POLLEN ASSEMBLAGE ZONE 4 (SPECTRA 32-34)

Pollen zone 4 reflects another forest clearance phase followed by the regeneration of the tree cover. *Pinus* as well as *Abies* show a temporary decline, whereas *Artemisia* and Chenopodiaceae reach again fairly high pollen percentages. The *Quercus* pollen curve has a distinct peak in zone 4, the *Juniperus* curve rises slightly and *Corylus* and *Ostrya/Carpinus orientalis* are represented. There are no clear indications of farming activities. It is true that in this zone Cerealia-type pollen has somewhat higher values, but this is no proof of cereal-growing. *Plantago lanceolata*-type pollen is conspicuously absent in sample 33, *Fraxinus ornus* continues to decline and pollen of *Juglans* and *Castanea* was not found. It seems likely that zone 4 reflects a forest-cutting period without subsequent use of the deforested terrain by farmers.

Pollen zone 4 can be dated from ca. 1,550 to 1,045 B.P.

7.3.7. POLLEN ASSEMBLAGE ZONE 5 (SPECTRA 35-39)

The greater part of pollen zone 5 reflects a continuous forest cover, in which *Pinus* must have been by far the dominant tree. *Abies* and *Cedrus* played only a minor part in the upland vegetation of the area, if their pollen had not already been brought in from a greater distance.

The upper two spectra point to increased human activity. The curves for Chenopodiaceae, Gramineae, Cerealia-type and *Plantago lanceolata*-type show a rise, whereas *Pinus* declines markedly. On the other hand, *Fraxinus ornus*, *Juglans* and *Castanea* are not represented in the upper two spectra, which is in agreement with the fact that at present these trees are not found in the area. The uppermost sample, at a depth of 5 cm, does not reflect the present-day vegetation pattern as is clear from a comparison with surface sample 56, from the south side of Beyşehir Gölü. In the latter sample *Pinus* and *Cedrus* values are lower and *Juniperus* and *Quercus* percentages much higher than in spectrum 39 of the Beyşehir diagram. This indicates that since the deposition of the sediment at a depth of 5 cm the degradation of the vegetation had proceeded further.

In pollen zone 5, the high values for Cyperaceae, *Sparganium*-type and *Dryopteris* decrease considerably. The disappearance of marsh vegetations from the vicinity of the coring site was probably due to a rise in the water level of the lake.

7.3.8. CLIMATIC IMPLICATIONS

It is likely that the expansion of pine at the expense of cedar at the zone 1/2 transition was caused by a change in climate. Whether this change in climate implied an increase or a decrease in humidity may be difficult to determine on the ground of the development of the vegetation. Both *Pinus nigra* and *Cedrus libani* show a wide ecological range.

The climate of zone 2 time was still more favourable for cedar than that of later periods. Because of the large-scale interference of man with the vegetation which is reflected in zone 3 the natural development of the vegetation was interrupted. The pollen record suggests that by the final stage of subzone 3e, *i.e.* 1,600 to 1,700 years ago, temperature and humidity had reached modern levels.

7.4. *HOYRAN GÖLÜ (fig. 17)*

7.4.1. THE GEOGRAPHICAL SITUATION

The Hoyran core was taken on the northern shore of Hoyran Gölü (fig. 16), ca. 3 km southeast of Asağikasikara (38°16′30″N, 30°52′30″E). Hoyran Gölü forms the northern part of a lake, the southern part of which is called Eğridir Gölü (vilayet of Isparta).

The lake is situated in a north-south orientated basin between the northwestern offshoots of the Beyşehir/Hoyran *nappes* and the eastern Lycian *nappes* (2.1.2.). The basin may be an intramontane valley which to the north and the south is closed by *nappes*. A narrow rift valley extends from Eğridir Gölü in a southern direction to Kovada Gölü. This *graben* cuts through the *nappes* and is consequently of a later date. It is not clear to what extent tectonics are also responsible for the origin of Eğridir-Hoyran Gölü.

On the slopes to the northwest, north, northeast and east of the lake, Neogene sediments are exposed over large areas. The other slopes consist of limestone, while to the west of Hoyran Gölü, Tertiary volcanic tuffs are exposed. To the west of the lake, the Barla Mountains reach elevations of more than 2,500 m.

The boring was carried out in a marshy zone between two low ridges. The elevation is ca. 920 m. Near the coring site the following plants were observed: *Butomus umbellatus*, *Scirpus lacustris*, *Phragmites australis*, *Scirpus* cf. *maritimus*, *Mentha* sp., *Veronica* cf. *anagallis-aquatica*, *Polygonum* sp., *Potamogeton* cf. *natans*, cf. *Nasturtium*.

The slopes to the north of Hoyran Gölü are partly treeless and partly covered by *Juniperus* woodland.

7.4.2. LITHOLOGY AND RADIOCARBON DATE

The following lithology was recorded:

0 -0.35 m	dark-grey clay
0.35-0.45 m	grey clay
0.45-1.35 m	marley clay with red-brown (oxidation) spots
1.35-1.65 m	grey clay with red-brown (oxidation) spots
1.65-2.00 m	dark-grey clay
2.00-2.85 m	grey clay, partly with red-brown (oxidation) spots
2.85-4.00 m	grey clay with dark spots
4.00-4.25 m	grey clay with some coarse sand and fine gravel
4.25-4.35 m	fine gravel with grey clay

A radiocarbon measurement was carried out for a sample from a depth of 1.65-1.80 m (organic fraction): 2,470 ± 50 B.P. (GrN-7324). A carbonate content of ca. 47% was determined for this sample.

7.4.3. REMARKS ON THE POLLEN DIAGRAM

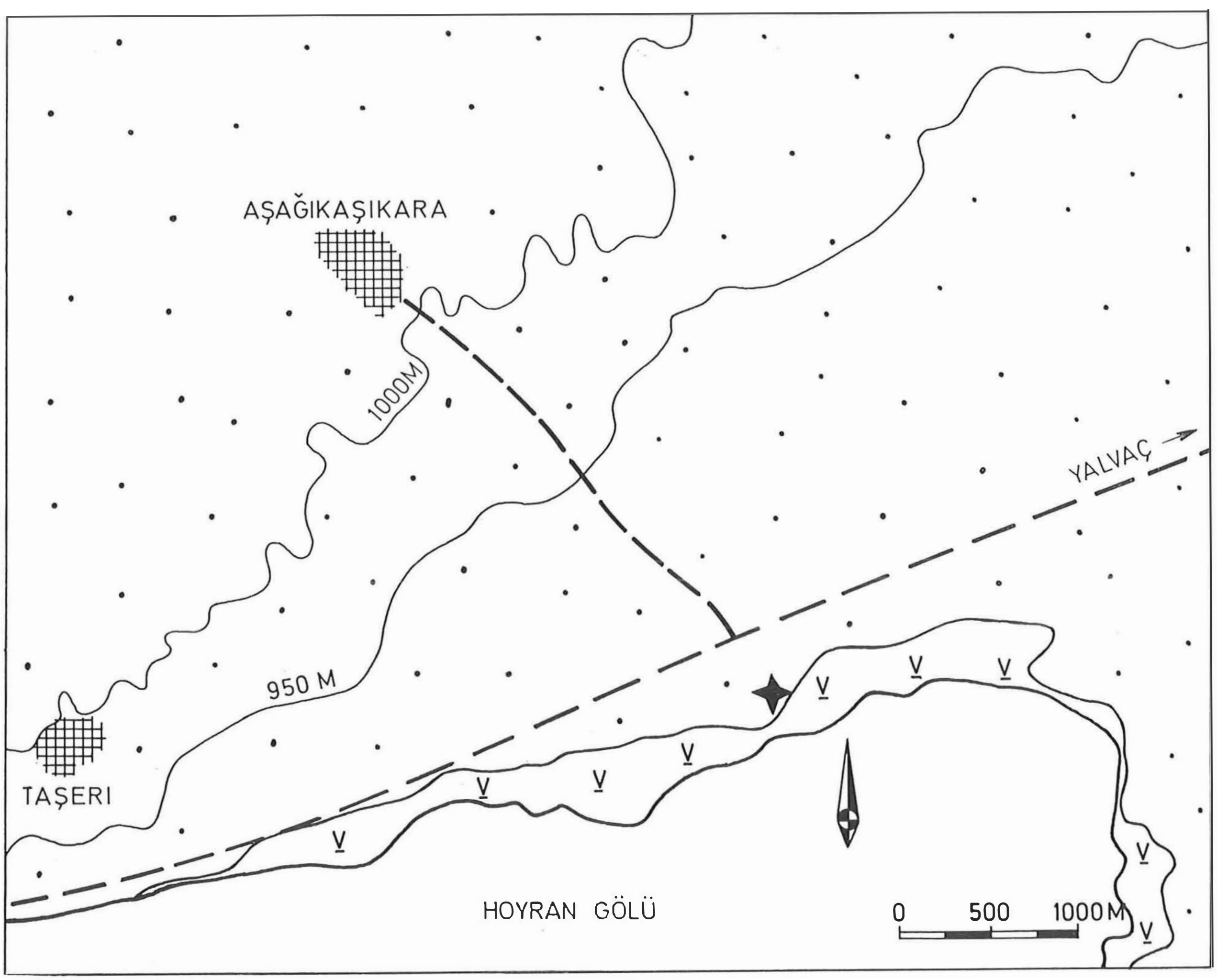
In the Hoyran diagram Chenopodiaceae are included in the pollen sum. However, high Chenopodiaceous percentages generally coincide with high values for Tubuliflorae Compositae and/or *Centaurea solstitialis*-type pollen. This indicates that the high Chenopodiaceous pollen values may have been caused by an expansion of chenopods on temporarily exposed lake shores rather than on the upland. For that reason, on the right of the diagram a "main diagram B" is drawn, in which Chenopodiaceae are not included in the pollen sum. The main diagram B may provide a better reflection of the relative proportions of trees and herbs in the upland vegetation.

In some sections of the Hoyran diagram, *Carya* shows relatively high pollen values. As has been discussed above (7.2.3.2.), the *Carya* pollen must have been redeposited. A likely source of *Carya* pollen are the Neogene deposits to the north of the lake. Although at present *Elaeagnus angustifolia* is a common tree along the banks of streams, it is likely that the *Elaeagnus* pollen in the Hoyran core is of secondary origin. In the other sediment cores from southwestern Turkey included in this study, *Elaeagnus* pollen was only once met with (Karamik, spectrum 28). *Aesculus* and *Fagus*, too, are most probably of secondary origin. One must assume that more pollen in the Hoyran core has been redeposited, but this cannot be proved.

7.4.4. POLLEN ASSEMBLAGE ZONE 1 (SPECTRA 1-3)

Spectra 1 and 2 are characterized by high tree pollen percentages, indicating that at that time forest vegetations prevailed in the area around the north side of Hoyran Gölü. *Artemisia* pollen values of 3-4% suggest that either steppe vege-

Fig. 16. Location of the Hoyran coring site. For explanation of symbols see fig. 13.



tations were found in the area to a limited extent or that the forest was fairly open. *Pinus* and *Cedrus* were by far the main constituents of the upland forests. Spectrum 3 forms the transition to zone 2.

The climate during zone 1 time was definitely favourable for tree growth and may have been very similar to that of to-day.

7.4.5. POLLEN ASSEMBLAGE ZONE 2 (SPECTRA 4-8)

This zone shows rather high ΣNAP values. Apart from Chenopodiaceous pollen which, in all probability, is largely of local origin (7.4.3.), the greater part of the herb pollen consists of that of *Artemisia* and Gramineae. Furthermore, various other herbaceous types, such as *Ephedra distachya*-type, *Polygonum aviculare*-type, Umbelliferae, *Valerianella* and *Scabiosa palaestina*-type, show maxima in zone 2. *Pinus* and *Cedrus* continue to be the quantitatively most important tree pollen types. *Quercus calliprinos*-type reaches slightly higher percentages, while deciduous oak is represented in the upper part of the zone.

During zone 2 time, steppic vegetations had partly replaced the coniferous forest to the north of Hoyran Gölü. Kermes oak, and at a later stage also deciduous oak, played a minor part in the tree and shrub vegetation of the area.

7.4.6. POLLEN ASSEMBLAGE ZONE 3 (SPECTRA 9-12)

ΣNAP percentages are high in zone 3, indicating that steppe vegetations, in which *Artemisia* and Gramineae continued to play a prominent part, had expanded further at the expense of the coniferous forest. It seems that, compared to zone 2, the proportion of the other herbs in the steppic vegetations had decreased.

7.4.7. POLLEN ASSEMBLAGE ZONE 4 (SPECTRA 13-17)

In the main diagram B, a continuous decrease in ΣNAP percentages can be observed, although in the upper part of the zone the *Artemisia* curve tends to rise slightly. The increase in total tree pollen percentages is brought about entirely by *Pinus* and *Cedrus*. Other arboreal taxa are represented by only low pollen percentages; only *Quercus cerris/infectoria*-type and *Alnus* show a continuous curve in this section.

In the course of zone 4 time, coniferous forest spread again over the area around the north side of Hoyran Gölü. The still rather high total herbaceous pollen values in the upper part of the zone, namely ca. 14% in the main diagram B, suggest that the forests were rather open, allowing a rich herbaceous ground cover. In the upper part of zone 4 the continuous *Abies* curve starts. Fir would have become at most an insignificant constituent of the coniferous forests in the area under consideration. It is also possible that *Abies* stands were found only at a greater distance from the Hoyran coring locality.

In zone 4, Cyperaceae and *Sparganium*-type percentages increase markedly, indicating that marsh vegetations had drawn near to the coring site.

7.4.8. THE INTERPRETATION OF POLLEN ZONES 2, 3 AND 4

Pollen assemblage zones 2, 3 and 4 reflect the expansion of steppic vegetations at the expense of coniferous forest and the subsequent return of the forest. The question arises whether this development of the vegetation was due to changes in climate or to the interference of man with the vegetation.

At first, before a radiocarbon date was available, it was supposed that, like the lower part of the Karamik diagram (7.2.3.), zones 2 and 3 of Hoyran represented a glacial period with a dry and cold climate. However, the radiocarbon date of 2,470 B.P. for the level between 1.65 and 1.80 m makes a Full-glacial age of pollen zones 2 and 3 less likely. If one assumes a more or less constant sedimentation rate for the whole of the Hoyran core (10 cm per ca. 143 years), the diagram should cover the last 5,700 years. Even if the sedimentation in the lower part of the core has taken place considerably more slowly than above 1.80 m, an age of more than 10,000 B.P. for the upper part of zone 3 is not very probable. Only in the case of a hiatus in the section between ca. 1.80 and 2.20 m, could zones 2 and 3 be of Full-glacial age.

If the whole Hoyran diagram is of Postglacial age, the strong expansion of open vegetations cannot have been caused by a change in climate, *i.e.* by a marked increase in dryness. For, in that case a similar reaction of the vegetation should have been found in the Karamik and Beyşehir diagrams, which are from the same area. Consequently, one wonders whether the drastic decline in forest acreage could have been the result of large-scale tree cutting. Assuming a constant sedimentation rate, the forest clearance period (zones 2 and 3) should have lasted from ca. 5,300 to 3,500 B.P. In the Karamik diagram (fig. 12), at a distance of ca. 20 km from the Hoyran coring site, the only indication of some opening up of the forest in the period mentioned above is provided by the small *Artemisia* maximum at a depth of 2.90 m (spectrum 34), with a calculated date of ca. 4,850 B.P. (7.2.5.). Consequently, any possible large-scale forest cutting must have been confined to the surroundings of Hoyran Gölü.

From the above it will be clear that a really satisfactory explanation cannot be presented for the changes in vegetation reflected in zones 2 to 4.

7.4.9. POLLEN ASSEMBLAGE ZONE 5 (SPECTRA 18-20)

This zone reflects a temporary and fairly limited expansion of steppic vegetations. The character of the open vegetation differed from that of zones 2 and 3 because now *Ranunculus* must have played an important part. In addition to *Artemisia* and *Ranunculus*, a large number of other herbaceous taxa is represented in zone 5, suggesting that the steppic vegetations were rich in species.

7.4.10. POLLEN ASSEMBLAGE ZONE 6 (SPECTRA 21-25)

Zone 6 is characterized by high ΣAP values, implying that the area was largely covered by pine and cedar forest. As during zone 5, kermes oak and deciduous oak were of some importance in the upland vegetation during the lower part of zone. 6 Oak species may have occurred mainly in the undergrowth of the coniferous forest. In the upper part of zone 6 the proportion of oak had fallen off.

In the main diagram B, the ΣNAP curve shows a slight rise in the upper part of zone 6, which is completely accounted for by the Gramineous percentages. The marked increase in Chenopodiaceous pollen values is accompanied by a similar rise in the curves for Liguliflorae Compositae and *Centaurea solstitialis*-type. Consequently, a local expansion of chenopods on the temporarily exposed lake shore seems likely.

7.4.11. POLLEN ASSEMBLAGE ZONE 7 (SPECTRA 26 AND 27)

Zone 7 shows a rise in the ΣNAP curve (main diagram B), which is brought about mainly by *Ranunculus repens*-type, Caryophyllaceae, *Brassica*-type and *Capsella*-type. On the other hand, *Artemisia* pollen values remain low. *Pinus* as well as *Cedrus* decline to some extent, but *Quercus calliprinos*-type and *Quercus cerris/infectoria*-type increase slightly.

The expansion of open vegetations was most probably caused by the activity of man. It is clear that the upper spectrum, at a depth of 10 cm, does not yet reflect the present-day vegetation to the north of Hoyran Gölü, in which juniper constitutes the most important arboreal species. During zone 7 time, marsh vegetations were again found in the vicinity of the coring site.

7.5. *SÖĞÜT GÖLÜ (fig. 19)*

7.5.1. THE GEOGRAPHICAL SITUATION

Söğüt Gölü (vilayets of Burdur and Antalya), at an elevation of 1,393 m, is located in an intramontane depression in the eastern Lycian *nappes*, the youngest of which are from the Miocene (Brunn *et al.* 1971). The basin is filled with Quaternary sediments. Neogene deposits are not exposed in the area. The slopes around the basin consist mainly of Mesozoic limestone. Ultrabasic rocks are exposed to the west and south of the basin. A highly calcareous Eocene flysch zone is found along the eastern edge of the basin. The highest peak of the Kizilcadağ mountains, to the south of the Söğüt basin, is over 2,500 m. The estimated annual precipitation at Söğüt is 700-800 mm.

Apart from some scattered *Juniperus*, the slopes around the basin are devoid of trees. The deforestation of the Söğüt area must have been of recent date (*cf.* 7.5.10.).

Söğüt Gölü (fig. 18) was surrounded by a marsh vegetation belt. In 1969, the lake was largely drained. The coring was carried out in the south-eastern part of the drained lake, ca. 7.5 km north-west of Kizilcadağ (37°03'N, 29°53'E). In the vicinity of the coring site the following plants were noted: *Phragmites australis*, *Agrostis*, *Juncus*, cf. *Nasturtium*, *Butomus umbellatus*, *Alisma plantago-aquatica*, *Scirpus*, *Veronica* cf. *anagallis-aquatica* and *Ranunculus* (sect. *Batrachium*).

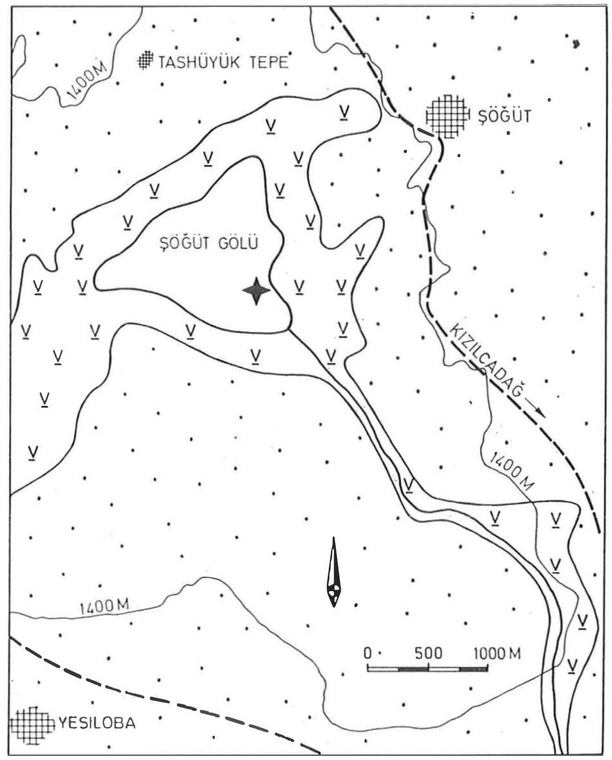


Fig. 18. Location of the Sögüt coring site. For explanation of symbols see fig. 13.

7.5.2. LITHOLOGY AND RADIOCARBON DATES

The following lithology was recorded:

0 -0.20 m	dark-grey clay
0.20-0.55 m	grey clay with dark spots
0.55-0.95 m	yellow-grey clay
0.95-1.45 m	grey clay
1.45-1.65 m	grey clay with red-brown (oxidation) spots
1.65-1.80 m	grey clay
1.80-2.00 m	grey clay with shells
2.00-3.40 m	black to dark-grey clay with shells
3.40-3.60 m	marl
3.60-5.35 m	blue-gray clay: the bottom of the basin was not reached

For two levels a radiocarbon date was obtained:

2.05-2.20 m organic fraction, 2,885 ± 35 B.P. (GrN-6452)

3.25-3.45 m organic fraction, 9,180 ± 95 B.P. (GrN-6883); $\delta C^{13} = -4.0‰$
calcareous fraction, 10,150 ± 130 B.P. (GrN-6889)

The carbonate content of the sample at 2.05-2.20 m was ca. 69%, that of the other sample ca. 86%.

7.5.3. REMARKS ON THE POLLEN DIAGRAM

Gramineae are not included in the pollen sum. The fact that high grass pollen percentages (spectra 12-13, 19-26, 28, 33-35) coincide with high values for *Sparganium*-type and/or Cyperaceae suggests that most of the Gramineous pollen in the samples concerned originated from the local marsh vegetation. As the comparatively high *Euphorbia* values in spectra 14 and 18-20 are probably also of local origin, this pollen type is not included in the pollen sum either.

The high Chenopodiaceae percentages in the section covered by samples 4 to 12 are accompanied by high values for Tubuliflorae and Liguliflorae Compositae and *Centaurea solstitialis*-type. This could indicate that one or more chenopod species expanded on temporarily exposed lake shores, so that a considerable proportion of the Chenopodiaceous pollen in the section concerned would be of local origin. On the other hand, the Chenopodiaceae maximum in spectra 15 and 16 is not paralleled by similar maxima in Compositae, whereas, in spite of high values for Tubuliflorae and *Centaurea solstitialis*-type in spectra 18-20, the Chenopodiaceous percentages remain low in this section. It is likely that the Chenopodiaceous pollen is largely of upland origin, and consequently this pollen type is included in the pollen sum. In the lower part of the diagram a certain parallelism between the curves for Tubuliflorae and *Matricaria*-type can be observed, which could indicate that at least part of the *Matricaria*-type pollen is of local origin.

The radiocarbon date of 2,885 B.P. for the level of 2.05-2.20 m points to an average accumulation of 10 cm sediment per 135 years for the upper part of the deposit. In the preceding period, between ca. 9,180 and 2,885 B.P., sedimentation was much slower, *viz.* 10 cm per 515 years. It is not probable that the sedimentation rate changed suddenly between 2.20 and 2.05 m. A gradual increase in the deposition of sediment is more likely, but where this started and how long it lasted cannot be determined without more radiocarbon dates. However, one must take into consideration that in the upper part of the section between 3.35 and 2.12^5 m, the sedimentation was probably more than 10 cm per 515 years, whereas in the lower part of the section above 2.12^5 m it was perhaps less than 10 cm per 135 years.

Because of the inequality in the average sedimentation rates in both sections, we did not feel we could date the pollen zones below a depth of 3.35 m by extrapolation of both radiocarbon dates.

7.5.4. POLLEN ASSEMBLAGE ZONE 1 (SPECTRA 1-3)

Zone 1 is characterized by high herbaceous pollen values, particularly for *Artemisia* and Chenopodiaceae. *Pinus* and *Quercus cerris/infectoria* constitute the quantitatively most important tree pollen types. The other trees represented in zone 1 include: *Cedrus*, *Betula*, *Ostrya/Carpinus orientalis* and *Acer*.

During zone 1 time, the greater part of the area was probably covered by steppe vegetations, in which *Artemisia* and Chenopodiaceae played an important part. Another vegetation type was formed by coniferous stands with pine and cedar. A third component consisted of broad-leaved trees, such as *Quercus*, *Ostrya carpinifolia* and/or *Carpinus orientalis* and *Acer*. Further, *Betula* would have been present. Although the possibility that during zone 1 time, the Söğüt area was largely covered by forest-steppe vegetations cannot be excluded, the authors visualize more a mosaic of steppe vegetations and tree stands.

We mentioned already that no satisfactory age calculation can be made for zones 1 to 3. There can, however, be no doubt that zone 1 dates from the last glacial period, implying considerably lower temperatures that at present. The high *Artemisia* percentages point to dry climatic conditions.

Similarly to the situation on the high plateaus of eastern Anatolia (Zohary 1973, p. 172), the relative scarcety of arboreal vegetation during zone 1 time may have been caused by a combination of strong winds and a short growing season. Precipitation may not have been the limiting factor. Trees and shrubs could grow only in places which were less exposed to the wind. Cloudy weather in the spring, resulting in little sunshine, could have been partly responsible for the short growing season.

7.5.5. POLLEN ASSEMBLAGE ZONE 2 (SPECTRA 4-9)

This zone is subdivided into two subzones. Subzone 2a (spectra 4-6) shows a distinct rise in *Quercus cerris/infectoria*-type percentages, whereas *Artemisia, Pinus* and *Cedrus* decrease. Chenopodiaceous pollen values are somewhat higher than in zone 1. The pollen evidence suggests an expansion of oak at the expense of the conifers. Deciduous oak not only replaced pine and cedar, but it probably also spread in formerly treeless areas. Of the other deciduous trees demonstrated for zone 1, only *Acer* may have increased somewhat at the beginning of subzone 2a. It seems that *Betula* had lost ground (its pollen is absent in spectrum 6), but *Hippophaë* is much better represented than in zone 1. It has already been mentioned (7.2.3.3.) that *Hippophaë* has a very wide ecological as well as geographical range.

During subzone 2a time, the vegetation pattern in the Söğüt area may still have consisted of a mosaic of steppe vegetations and tree or shrub stands, although the fairly high *Quercus* pollen percentages could likewise point to predominantly oak forest-steppe and steppe-forest vegetations.

In subzone 2b (spectra 7-9), ΣNAP again reaches the same values as in zone 1, but *Artemisia* hardly participates in the increase. The *Quercus* curve shows a sharp decline between spectra 6 and 7; *Cedrus* and *Ostrya/Carpinus orientalis* are not represented in this subzone. The proportion of deciduous oak in the vegetation decreased at the transition from subzone 2a to subzone 2b. This, however, was not accompanied by a re-establishment of conifers in the area.

At first sight, the change in vegetation that took place at the beginning of zone 2 seems difficult to explain in terms of climatic changes. For, in subzone 2a, the conditions became more favourable for oak, but at the same time unsuitable for pine and cedar, which must have disappeared from the Söğüt area. One wonders whether the climate of subzone 2a time was warmer as well as drier than that of zone 1. The increased temperatures, implying a longer growing season, could have favoured the expansion of oak, whereas at the same time it became too dry for *Pinus* and *Cedrus.* In this respect it should be remembered that at present deciduous oak penetrates further into the dry steppe areas of Central Anatolia than conifers do. The increased share of chenopods in the vegetation of subzone 2a time may likewise have been the result of a drier climate. The greater dryness does not necessarily imply a decrease in precipitation. It may have been caused by the rise in temperature.

It looks as if at the beginning of subzone 2b time the dryness increased further, as a result of which deciduous oak declined. The presence of *Quercus calliprinos* in this subzone, under dry and not too cold climatic conditions, is not astonishing. It is striking that in this subzone *Acer* and *Ostrya/Carpinus orientalis*, which are less xeric than some of the deciduous oak species, are not present, or hardly at all. On the other hand, the representation of *Corylus* is difficult to reconsile with a dry climate. One wonders as to how far the pollen of hazel, and also of other taxa, must be ascribed to long-distance transport or to redeposition. The occurrence of *Alnus* pollen in zone 2 and in other sections of the diagram points to the presence of edaphically suitable habitats for alder along the banks of streams and the like.

7.5.6. POLLEN ASSEMBLAGE ZONE 3 (SPECTRA 10-18)

Zone 3 is subdivided into 3 subzones. Subzone 3a (spectra 10-12) has low ΣAP values, 20% on the average. *Quercus cerris/infectoria*-type accounts wholly for the decrease in tree pollen values, whereas *Pinus* and *Cedrus* even show a slight increase. It is clear that the pollen record of subzone 3a is the reflection of largely treeless vegetations. Forest stands were probably confined to a few places. The question arises which trees were found in these scattered forest stands. Do the increased values for pine and cedar in spectra 11 and 12 indicate that these conifers were again present in the Söğüt area? There is reason to doubt whether this is true. The low pollen sums in samples 11 and 12, *viz.* 101 and 108 respectively, suggest a low pollen production by the upland vegetation of the Söğüt area. As a result, the proportion of long-distance pollen in the spectra concerned may be quite high. As cedar and, in particular, pine have a good pollen dispersal, the representation of these taxa in samples 11 and 12 may be entirely due to long-distance transport. In addition to oak, *Betula* and *Hippophaë* may have occurred in the Söğüt area at the time.

In subzone 3b (spectrum 13), tree pollen values account for more than 50%. *Quercus* and *Pinus* show fairly high percentages, *Cedrus* reaches 3.5% and, for the first time, *Juniperus* is represented by a somewhat larger number of pollen grains. During this subzone, the vegetation pattern may have been rather similar to that of subzone 2a, but now in addition to oak groves, juniper and pine-cedar stands were found.

In subzone 3c (spectra 14-18), arboreal pollen percentages are low again, with a minimum value of 7.5% in spectrum 16. A conspicuous feature of this subzone are the extremely high *Artemisia* percentages, up to more than 60%. The zone 3/4 contact is placed between spectra 18 and 19. It is true that the rise in arboreal pollen starts from a lower level, but the sharp decline in the *Artemisia* curve takes place between spectra 18 and 19.

During subzone 3c time, the vegetation of the Söğüt area was most probably a steppe with only very scattered stands of *Quercus* and *Betula. Artemisia* played a predominant part in the steppe vegetations, but the proportion of Chenopodiaceae would have been smaller than in the preceding periods. On the other hand, *Ephedra* was more common in the vegetation of subzone 3c than before.

The climate of subzone 3a time must have been very unfavourable for tree growth. The relatively high pollen percentages for oak and pine in sample 13 (subzone 3b) point to a quite considerable amelioration of climate compared to that of the previous subzone. Precipitation, in particular, must have increased markedly.

The climate of subzone 3c time must again have been characterized by a greater dryness. During this subzone, conditions for tree growth became more adverse than during any other period represented in the Söğüt diagram. One wonders whether the relatively high *Quercus calliprinos*-type percentages, the presence of *Ostrya/Carpinus orientalis* and the increase in *Juniperus* in spectra 17 and 18 could point to the return of a somewhat moister climate. The upper limit of zone 3, at a depth of 3.25 m, has a calculated date of 8,670 B.P. The amelioration in climate and the initially slow increase in trees may have started some 10,000 years ago.

7.5.7. POLLEN ASSEMBLAGE ZONE 4 (SPECTRA 19-26)

At the beginning of zone 4 the *Artemisia* curve shows a sharp decline. The decrease of the total herbaceous pollen percentages is more gradual and the lowest values are reached at the top of this zone (spectra 25 and 26). The steady decline in the herbaceous pollen percentages is interrupted by a low maximum in spectrum 24. *Pinus* attains a value of ca. 30% in spectrum 20, falls back to about 12% in spectrum 24, and shows again ca. 30% values in spectra 25 and 26. From the base of zone 4 on, the *Quercus cerris/infectoria*-type curve rises, although not steadily, to more than 45% in spectrum 24, and declines subsequently in the upper part of the zone. *Juniperus* reaches similar high percentages in this zone, with a maximum of 30% in spectrum 23. From spectrum 20 onwards *Cedrus* is represented in low percentages.

An attempt to reconstruct the vegetation pattern during zone 4 time meets difficulties. It is reasonable to assume the presence of oak and pine forests. The distribution of both forest types must have been determined by altitude and exposure. One could imagine that oak forests were found particularly at lower elevations in and around the Söğüt basin, whereas pine forests occurred above the deciduous forest belt, where the humidity was somewhat higher. The *Quercus* maximum and *Pinus* minimum in spectrum 24 could point to a temporary expansion of the oak forest belt at the expense of the coniferous forest.

The question remains whether *Juniperus* formed separate stands or whether this tree occurred together with either *Quercus* or *Pinus*. The course of the curves for these three types does not provide any clues to solve this question. The lower part of zone 4, spectra 19-23, suggests a co-existence of oak and juniper, but in the upper part of the zone, spectra 24-26, the curves for both pine and juniper show a distinct rise. The expansion of oak in the period represented by spectrum 24, affected both pine and juniper. On the other hand, in zones 5, 6 and 7, the course of the curve for juniper is fairly identical to that for oak. Mixed stands of juniper and pine (*Pinus nigra-Juniperus excelsa* forests) as well as of juniper and oak (*Quercus pubescens-Juniperus excelsa* forests) are reported for Turkey by Zohary 1973 (pp. 287 and 293). However, *Juniperus* may similarly have formed a separate forest type. In any case, the behaviour of juniper was independent of that of pine and oak.

The behaviour of *Cedrus* in subzone 6a (7.5.9.) suggests that in the Söğüt area cedar did not occur in mixed stands with pine, juniper or deciduous oak. Very probably cedar forests were found at a somewhat greater distance from the valley bottom.

Interpolation of both radiocarbon dates available for the Söğüt core results in a date of ca. 3,655 B.P. for the zone 4/5 boundary at 2.27^5 m. As the sedimentation rate in the upper part of zone 4 may have been higher than the average of 10 cm per 515 years for the section between 3.35 and 2.12^5 m (7.5.3.), the date of 3,655 B.P. is probably too old and the zone contact may date from several hundred years later.

The replacement of steppe vegetations by forests must have been the result of a marked increase in humidity. The rather slow spread of trees (ca. 3,000 years elapsed between spectra 18 and 23) suggests a gradual increase in humidity. During zone 4 time, temperatures were most probably somewhat higher than at present. The humidity, on the other hand, would not have reached modern levels. The latter conclusion is based upon a comparison of the present-day natural vegetation with that of zone 4 time. The upper part of the Söğüt diagram (7.5.10.) indicates that without the interference of man the slopes around the Söğüt basin would still be covered by predominantly pine forest. The large proportion of deciduous oak in the forest vegetations of zone 4 time suggests that the climate was drier than at present. In this connection it should be remembered that some deciduous oak species, such as *Quercus cerris* and Q. *pubescens*, are more drought-resistant than pine.

7.5.8. POLLEN ASSEMBLAGE ZONE 5 (SPECTRUM 27)

Although zone 5 consists of only one spectrum, it has been distinguished as a separate zone because of the important change in vegetation reflected in the spectrum concerned. Zone 5 shows a marked increase in *Pinus* and a decrease in *Quercus* and *Juniperus*, suggesting an expansion of pine forest in areas formerly occupied by oak and juniper. The development of the natural vegetation in the Söğüt area was interrupted by the interference of man (7.5.9.). The expansion of pine points to an increase in humidity.

7.5.9. POLLEN ASSEMBLAGE ZONE 6 (SPECTRA 28-40)

In subzone 6a (spectra 28-37), a nearly continuous decrease in ΣAP percentages takes place. This decline includes *Pinus* as well as *Quercus cerris/ infectoria*-type and *Juniperus*. In the upper part of this subzone, *Juniperus* pollen values have dropped to nearly zero. In spite of the decline in total tree pollen values, *Olea*, *Fraxinus ornus*, *Quercus calliprinos*-type, *Juglans* and *Vitis* show the highest percentages of the whole diagram in subzone 6a. Moreover, *Ulmus*, *Alnus*, *Corylus* and *Betula* are represented by relatively high percentages. *Artemisia*, Cerealia-type, *Plantago lanceolata*-type, *Brassica*-type and many other types participate in the increase in herbaceous pollen values.

In subzone 6b (spectra 38-40) a strong increase in tree pollen can be observed. This increase is completely accounted for by *Pinus*, as all other arboreal pollen types, except *Cedrus*, decrease. The decline in herbaceous pollen involves many types.

Similarly to zone 3 of the Beyşehir diagram, zone 6 of the Söğüt diagram reflects large-scale and long-lasting forest-cutting and farming activities, followed by a regeneration of the forest. In the Söğüt diagram two phases can be distinguished, *viz.* a phase with steadily decreasing ΣAP values and consequently increasing herbaceous pollen percentages (subzone 6a), and a renewed rise of the ΣAP curve (subzone 6b). In the course of the period of habitation, the Söğüt farmers must have gradually expanded the cleared terrain.

The deforestation probably affected pine as well as oak and juniper, although it cannot be determined as to what extent a change in climate contributed to the decrease of *Quercus* and *Juniperus*. In this connection it is significant that oak and juniper did not participate in the regeneration of the forest (subzone 6b). One must assume that in the final stages of the colonization a large part of the Söğüt area was devoid of forest.

It is striking that cedar did not suffer from the forest-clearing activities. At least the *Cedrus* curve does not show a decline in subzone 6a. This indicates that this tree was not present, or hardly at all, on the slopes around the basin, which were affected by the activities of man. Apparently, cedar forests were found only at some greater distance from the coring site.

As at Beyşhir, the Söğüt farmers cultivated *Olea europaea*, *Juglans regia*, *Vitis vinifera* and *Fraxinus ornus* (see 7.3.5.3.). *Castanea sativa* is hardly represented in the Söğüt diagram (spectra 29 and 31), indicating that this fruit tree must have been of minor importance here. The earlier cultivation of olive in the Söğüt area, at elevations of 1,400 m and more, may point to milder winters than at present. Nowadays *Olea* is not cultivated in the Söğüt area, and this tree does not usually occur above 1,200 m in southwestern Turkey. The *Olea* pollen curve shows a drop in the upper part of subzone 6a, which indicates that olive cultivation declined in the final stages of the land occupation. The pollen evidence suggests that the cultivation of *Fraxinus ornus* was given up long before the area was abandoned.

Quercus calliprinos, *Betula* and *Corylus* profited to some extent from the activities of the Söğüt farmers. The fall of the Q. *calliprinos*-type curve in the upper part of subzone 6a suggests that in the course of the period of habitation the proportion of kermes oak decreased markedly. One wonders whether this could have been due to a more intensive collecting of fire wood, particularly in the valley and on the lower parts of the slopes.

The comparatively high Cerealia-type pollen values in subzone 6a may be a reflection of graingrowing by the Söğüt farmers. The complications with respect to palynological evidence for grain-growing in the Near East have already been discussed (7.3.5.2.). Attention should be paid to the *Humulus/Cannabis* pollen type, which shows a continuous curve in subzone 6a. There can be little doubt that either *Humulus* or *Cannabis* was grown by the Söğüt farmers. Although Godwin (1967) claims that the pollen of *Cannabis* can be separated from that of *Humulus*, the present authors do not feel able to make this distinction. Consequently, on the basis of the pollen evidence it cannot be ascertained whether hemp or hop was cultivated in the Söğüt area. The beginnings of the use of hop cones in brewing beer are still obscure, although beer itself had already been known to the Babylonians since about 4,000 B.C. So far, palaeobotanical and literary evidence for the cultivation of *Cannabis sativa* dates back to the second half of the first millennium B.C. Thus, Herodote (ca. 484 B.C.) reports that the Scytes and the Thracians, who lived north and west of the Black Sea, cultivated hemp. From the above it will be clear that the available data do not provide an indication for determining which species produced the *Humulus/Cannabis* pollen type in subzone 6a of the Söğüt diagram.

The curve for *Plantago lanceolata*-type pollen shows a distinct rise in the course of subzone 6a, suggesting that the grazed area expanded as the deforestation proceeded. Not only do various herbaceous pollen types show fairly high percentages in this subzone, but also the number of types is markedly great. The large-scale forest clearances must have favoured the development of a herbaceous plant cover which was rich in species as well as in individuals, particularly if the grazing pressure was not too serious, for over-grazing results in the elimination of many species.

In the land-occupation section of both the Beyşehir (7.3.5.5.) and the Söğüt diagrams, *Sanguisorba minor*-type pollen is present in relatively high percentages. One wonders whether this pollen type could have originated from *Poterium* (*Sarcopoterium*) *spinosum*, a spiny dwarf shrub which is very common in seriously degraded vegetations in the Eu-Mediterranean zone. It is true that this species is found up to 1,200 m, but its optimal range is from 100 to 700 m (Zohary 1973, p. 397). Consequently, it is not very likely that it was *Poterium spinosum* which played a fairly important part in the secondary vegetations at Beyşehir and Söğüt. It seems more probable that *Sanguisorba minor* was involved.

Concerning the duration of the forest-cutting and farming activities reflected in subzone 6a, which covers the section between 2.12^5 and 1.40 m, the following remarks can be made. The average sedimentation rate of 10 cm per 135 years in the section between 2.12^5 m and the surface implies an occupation of ca. 1,000 years. The colonization of the area in and around the Söğüt basin must have lasted from ca. 2,885 to 1,900 B.P. (935 B.C.-50 A.D.). If in the section covered by subzone 6a the sedimentation was somewhat less than 10 cm per 135 years (7.3.5.), the land-occupation period must have lasted longer. It is, however, unlikely that it was considerably more than the calculated 1,000 years.

The regeneration of the forest, subzone 6b, covering the section between 1.40 and 1.10 m, lasted ca. 400 years. By 1,500 B.P. the whole area was again covered by forest.

7.5.10. POLLEN ASSEMBLAGE ZONE 7 (SPECTRA 41-51)

Zone 7 is characterized by very high *Pinus* pollen percentages. Of the other trees, only *Cedrus* shows a continuous curve with values between ca. 2 and 6%. Herbaceous pollen values are insignificant; of the types included in the pollen sum, only *Artemisia* is represented in all the spectra of this zone.

During zone 7 time, the Söğüt area was covered by coniferous forests with predominantly pine. Cedar must have been of minor importance. Deciduous oak and juniper, which played a very important part in the vegetation pattern of the Söğüt area during zone 4 time, must only rarely have been found here during zone 7 time.

It should be remarked that the modern tree cutting, which resulted in the complete deforestation of the Söğüt area, is not represented in the diagram. Even the possible beginning of the large-scale deforestation is not indicated in the diagram. This is somewhat strange, as the core was taken in a part of the drained lake which had not yet been brought into cultivation. Apparently, the top of the sediment had disappeared, perhaps as a result of wind erosion of the exposed surface.

The plant cover reflected in zone 7 may be considered as the climax vegetation under present-day climatic conditions. This would indicate that at the beginning of the zone, *i.e.* ca. 1,500 years ago, precipitation and temperature had reached modern levels. It has already been suggested that the expansion of pine at the expense of oak and juniper in zone 5 could point to an increase in humidity. Due to the interference of man, the natural development of the vegetation was interrupted during subzone 6a time. However, the fact that oak and juniper did not participate in the reforestation reflected in subzone 6b may indicate that during subzone 6a time the humidity had increased further. The decrease in *Olea* in the upper part of subzone 6a could be an indication of a fall in winter temperatures. Olives are not resistant to severe frost. The increase in humidity to modern levels probably started in zone 5 time, while indications of a drop in winter temperatures date back to the upper part of subzone 6a. It is possible that summer temperatures also decreased, but on this point the palynological evidence does not provide information.

7.5.11. THE LOCAL VEGETATION

The fairly high pollen values for Tubuliflorae and Liguliflorae Compositae and *Centaurea solstitialis*-type in the section between 5.10 and 3,95 m, point to fluctuating lake levels (7.1.). The greater part of the section between 4.10 and 1.40 m is characterized by high percentages for one or several marsh plant taxa (*Sparganium*-type, Cyperaceae, Gramineae), suggesting that marsh vegetations were found near the coring locality. In this section, *Myriophyllum*, *Nymphaea* and *Ranunculus peltatus*-type (of which the last-mentioned pollen type includes some species of the subgenus *Batrachium*) are present. Pollen of these water plants was counted in particularly large numbers between 1.95 and 1.55 m, indicating that at that time water-milfoil, water-lily and water crowfoot must have been very common there.

Apparently, extensive marsh vegetations can also maintain themselves under circumstances of fluctuating lake levels. At least the high percentages for Tubuliflorae and *Centaurea solstitialis*-type in spectra 18-20 suggest intermittently exposed lake shores. It is not clear whether *Euphorbia*, rather high pollen percentages of which were established for spectra 14 and 18-20, formed part of the marsh vegetation or of the plant cover on exposed lake shores. It is striking that the maxima in the *Euphorbia* curve coincide with maxima in the curve for *Lycopodium*, which may also have formed part of the local vegetation. At present, *Lycopodium* species are not found in southwestern Turkey (Davis 1965, pp. 35-36).

The upper part of the core, above 1.40 m, does not generally show conspicuously high percentages for taxa from the local vegetation. It seems that the lake level was fairly high, in consequence of which marsh vegetations and vegetations from exposed lake shores were found only at a greater distance from the coring site.

7.6. *KÖYCEĞIZ GÖLÜ (fig. 22)*

7.6.1. THE GEOGRAPHICAL SITUATION

Köyceğiz Gölü (vilayet of Muğla) is situated in the Köyceğiz Plain (fig. 20). A soil survey was carried out in the Köyceğiz-Dalaman area by Pons and Edelman (1963). The following is mainly taken from their publication.

The Köyceğiz Plain forms part of a small rift valley. The tectonics involved are still active, and historical earthquakes are known. The plain is surrounded by hills and mountains consisting of Mesozoic limestone and ultrabasic rocks. Neogene deposits are not exposed in the area, but the Dalaman river, which once may have run into the lake, cuts through Neogene layers in its upper courses.

The meandering Dalyan river connects Köyceğiz Gölü with the sea. Peat deposits are found along the southeastern bank of the lake and particularly along the sea coast to south of the lake.

The water of the lake, which is up to 35 m deep, is brackish to nearly salty, with a superficial layer of slightly brackish to fresh water. The soil to the southeast of the lake is saline. During the winter the water in the Dalyan river runs into the sea, draining Köyceğiz Gölü. During the summer considerable quantities of sea water flow into the lake.

During the last glacial period, when the sea-level was up to 100 m lower than at present, no lake would have been found in the Köyceğiz Plain. During this period coarse colluvial and fluvial material was deposited in the plain. The lake was probably formed in Holocene times, after the sea-level had risen considerably.

The slopes to the west and south of the lake are covered by *Pinus brutia* forest and maquis with predominantly *Quercus calliprinos*. *Tamarix* is common in the marshes along the southeastern bank of the lake. Halophytic vegetations, including *Salicornia*, *Statice*, *Frankenia* and *Juncus maritimus*, occur on saline soils. More to the east, the plain has been drained and is under cultivation. On the peat bordering the lake, *Phragmites australis*, *Cladium mariscus*, *Juncus* spec., *Scirpus* spec., *Convolvulus* spec. and other species were observed. *Platanus*, *Ulmus* and *Salix* grow along the Dalyan river, north of Dalyanköy. According to Pons & Edelman (1963) swamp forests with *Liquidambar orientalis* cover large areas in the lower parts of the Köyceğiz-Dalaman Plain.

Rainy, very mild winters and dry, hot summers characterize the climate. The annual precipitation at Fethiye, ca. 55 km southeast of Köyceğiz, is ca. 1,000 mm. Temperatures rarely drop below 0°C.

The boring was carried out on the peaty fringe of the southeastern bank of the lake (fig. 21), ca. 4 km north of the village of Dalyanköy (36°52′30″ N, 28°38′30″E). The surface at the coring locality is ca. 0.75 m above lake level.

7.6.2. LITHOLOGY AND RADIOCARBON DATES

The following lithology was recorded:

0 -0.25	m	grey, peaty clay
0.25-1.13	m	brown peat
1.13-1.35	m	dark-grey clay
1.35-2.65	m	blue-grey clay
2.65-2.90	m	blue-grey clay with sandy layers
2.90-3.75	m	blue-grey clay
3.75-4.14	m	grey-brown gyttja
4.14-4.23	m	grey, clayey sand
4.23-4.85	m	blue-grey clay
4.85-5.25	m	sandy, blue-grey clay
5.25-5.65	m	blue-grey clay
5.65-6.10	m	very sandy, blue-grey clay
6.10-6.18	m	dark-grey clay
6.18-6.40	m	blue-grey clay
6.40	m	coarse sand and fine gravel; further penetration impossible because of course sediment

For two levels a radiocarbon date was obtained:
0.85-1.05 m, 465 ± 30 B.P. (GrN-6641), peat
3.89-4.01 m, 3,070 ± 55 B.P. (GrN-6451), gyttja
The organic fraction was measured. The carbonate content of the radiocarbon dated samples amounted to ca. 32% and 27% respectively.

7.6.3. REMARKS ON THE POLLEN DIAGRAM

In the Köyceğiz diagram, Gramineae and Chenopodiaceae are not included in the pollen sum. The fact that high Cyperaceous pollen values correspond with maxima in the Gramineous curve suggests that the grass pollen is largely of local origin. Moreover, both pollen types show their highest values in the sections with peat or gyttja. The Chenopodiaceous pollen frequencies are very irregular and most probably register local expansions of halophytic vegetations.

The discussion of the Köyceğiz diagram will not start with the lowermost pollen assemblage zone. Contrary to the usual procedure, a few other sections of the diagram will be discussed first. Next the development of the regional vegetation in the Köyceğiz area will be reviewed, and this will be followed by a discussion of the local vegetation.

7.6.4. INDICATIONS OF HUMAN ACTIVITY AND THE ARTEMISIA PROBLEM

On the basis of both radiocarbon dates, the bottom of the diagram may be dated at ca. 5,000 B.P., *i.e.* in the Early Bronze Age. This implies that the diagram covers a period, in which more or less serious interference of man with the vegetation is to be expected. Which indications of the activity of man are provided by the pollen record? In general *Pinus* pollen percentages are much higher than those of *Quercus*. However, in a few diagram sections, *viz.* spectra 1-2, 10-11 and 16-19, *Quercus* values are nearly as high as those of *Pinus*. In view of the results obtained for Beyşehir, where the distinct land-occupation phase is characterized by, among other things, a strong decrease in pine and an increase in oak pollen percentages, it is an obvious

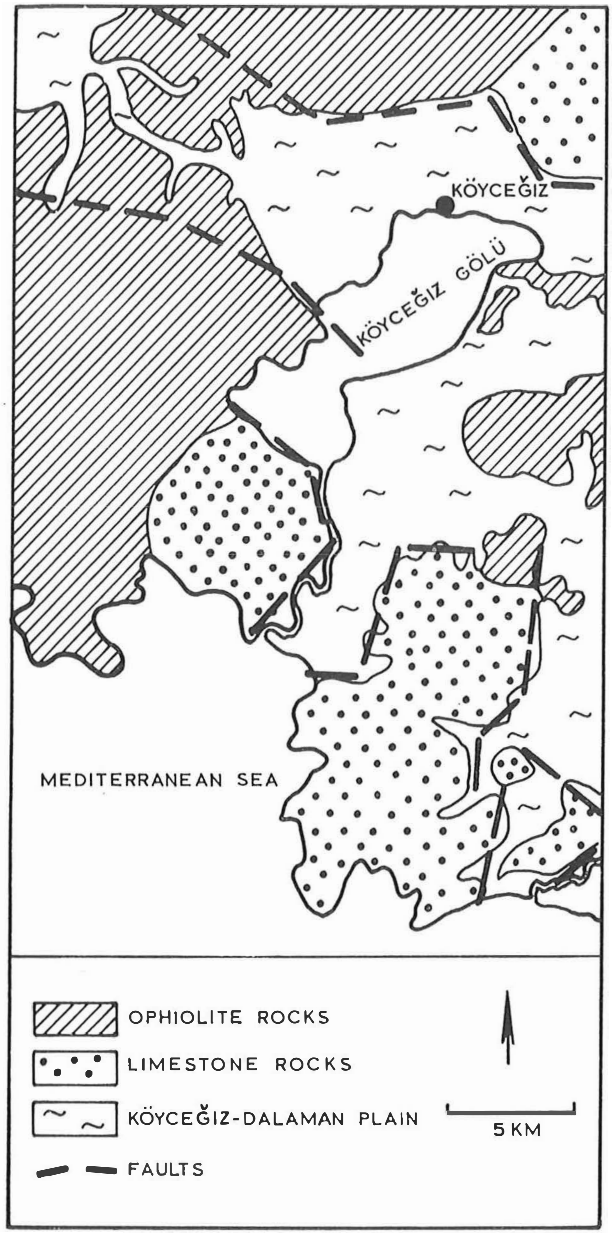


Fig. 20. Geological sketch map of the Köycegiz area. After Pons & Edelman 1963, fig. 4.

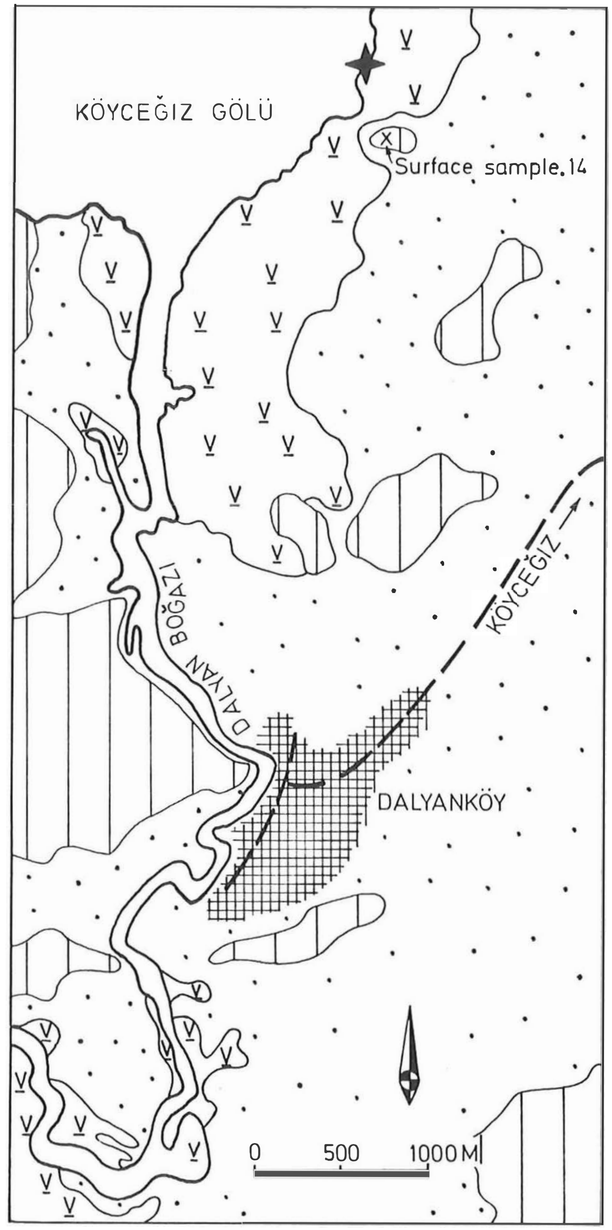


Fig. 21. Location of the Köycegiz coring site. For explanation of symbols see fig. 13.

conclusion that the sections mentioned above represent periods of more intensive human activity.

The strong decline in *Pinus* and the synchronous increase in *Quercus* pollen percentages between spectra 15 and 18 suggest a large-scale cutting of pine which favoured the expansion of oak. As for the kind of oak, when the Köyceğiz sediment samples were examined, no distinction was made between the pollen of the Q. *calliprinos*-type and that of deciduous oak (Q. *cerris/infectoria*-type). A re-examination of samples 16 and 17 showed that the majority of the oak pollen is of the Q. *cerris/infectoria*-type. Q. *calliprinos*-type pollen percentages are indicated by black bars. The opening up of the *Pinus brutia* forest did not result in a strong increase in kermes oak as happens nowadays, but deciduous oak took possession of the deforested areas.

The partial replacement of pine by oak is not necessarily the result of human activity. It could, at least in theory, also have been induced by a change in climate. Fortunately, the pollen record provides independent indications of the activity of man. Thus, *Olea* and *Vitis* show comparatively high values in the diagram section concerned. It is true that olive, in particular, formed part of the natural vegetation, but its pollen values in spectra 16-19 justify the assumption that *Olea* was cultivated. The fairly high *Plantago lanceolata*-type pollen percentages point to grazing. *Sanguisorba minor*-type, which includes *Poterium* (*Sarcopoterium*) *spinosum*, is well represented in zone 4, suggesting that open vegetations were present. Open vegetations are likewise indicated by the more frequent occurrence of pollen of the maquis species *Phillyrea* (*media*), *Pistacia* (*lentiscus* and *palaestina*), *Paliurus* (*spina-christi*) and Ericaceae in this section.

To summarize, it seems justified to conclude that pollen assemblage zone 4 reflects the activity of man. More puzzling is the succeeding diagram section. Above spectrum 19, the *Quercus* pollen curve shows a conspicuous decline which, however, is not accompanied by an increase in *Pinus* values. On the other hand, the *Artemisia* pollen percentages increase rapidly above spectrum 19, suggesting that the deciduous oak stands were replaced by vegetations with predominantly *Artemisia*. However, this assumption is not without objections, as at present upland vegetations in which *Artemisia* plays a dominant part are not found in the Eu-Mediterranean zone. In the surface-sample spectra from the lower and upper Eu-Mediterranean zones, *Artemisia* values do not exceed 1.3% (tables 1 and 2). Nearly all *Artemisia* pollen in the Köyceğiz samples is of the *herba-alba* type.

In view of the fact that halophytic vegetations occur to the east of the lake, one could wonder whether the large numbers of *Artemisia* pollen had originated from *A. maritima* which has pollen of the *herba-alba* type. However, *A. maritima* seems to be rare in the Eastern Mediterranean, and the present authors did not observe this species among the salt plants to the east of the lake, nor is it reported by Pons & Edelman (1963) for the same area. Moreover, maxima in the Chenopodiaceous curve, probably pointing to local expansions of halophytic vegetations, are not accompanied by high *Artemisia* percentages. Consequently, it is very unlikely that *A. maritima* produced the large numbers of *Artemisia* pollen. *A. vulgaris*, a plant from roadsides and waste places, does not come into consideration because it has another pollen type.

It has already been mentioned that the present-day interference of man with the vegetation of the Eu-Mediterranean zone never results in a large-scale expansion of *Artemisia*. Nevertheless, one is forced to assume that the high *Artemisia* pollen values, such as have been established for spectra 20-26, were the result of the activity of man. The question as to whether the strong increase in *Artemisia* was induced by grazing, burning or by some other activity must remain unanswered.

7.6.5. POLLEN ASSEMBLAGE ZONE 1 (SPECTRA 1 AND 2)

This zone is characterized by relatively low *Pinus* and high *Quercus* pollen values. The greater part of the *Quercus* pollen is of the deciduous oak type: 27.0% Q. *cerris/infectoria*-type and 4.2% Q. *calliprinos*-type in spectrum 1. *Vitis* and *Olea* are represented, while in sample 2 *Artemisia* pollen is quite numerous. Zone 1 reflects a situation which to some extent may be compared to that of zones 4 and 5a (7.6.4.).

7.6.6. POLLEN ASSEMBLAGE ZONE 2 (SPECTRA 3-7)

This section probably reflects a largely undisturbed upland vegetation. *Pinus* is by far the most frequent tree pollen type. Most of the *Quercus* pollen is of the Q. *cerris/infectoria*-type (see spectrum 6 in which the share of Q. *calliprinos*-type is indicated). *Olea* is hardly represented, while *Vitis* pollen was not met with in the samples from this zone. The herbaceous pollen values are low. The upland vegetation must have consisted of a mozaic of *Pinus brutia* and *Quercus infectoria* stands or of mixed pine-oak forests. It should be emphasized here that the pollen record suggests that by nature pine plays an important part in the (lower) Eu-Mediterranean vegetation belt. The suggestion that *Pinus* expanded considerably as a result of the destruction of the original maquis vegetation (*cf.* 4.2.) is not supported by the pollen evidence.

7.6.7. POLLEN ASSEMBLAGE ZONE 3 (SPECTRA 8-15)

This zone is rather heterogeneous and for that reason a division into subzones was made. Subzone 3a, consisting of spectrum 8, is characterized by a distinct *Pinus* minimum and a conspicuously high *Pteridium* value (21%). This spectrum suggests that bracken expanded notably in cleared areas. It is likely that spectrum 8 reflects a large-scale cutting of pine trees.

Spectrum 9, at which subzone 3b starts, suggests that pine had recovered from the losses brought about by the cutting. At the same time *Vitis* and *Olea* appear again in the pollen record, indicating that these species were cultivated. Grape and olive are also represented in spectrum 10. In spectra 10 and 11, *Pinus* has again relatively low pollen values, whereas *Quercus* percentages have increased. The course of the *Pinus* and *Quercus* curves in the lower part of subzone 3b suggests a similar land-occupation phase as has been described for zone 4 (7.6.4.). However, in spectrum 11 other indications of human activity, such as the pollen of *Vitis*, *Olea* and *Plantago lanceolata*-type, are absent.

Concerning spectra 10, 11 and 12, it should be taken into consideration that the pollen sums are quite low, while most of the pollen was in a fairly poor state of preservation. Moreover, samples at 5.00, 4.90 and 4.70 m proved to be unsuitable for pollen analysis. The sediment section between 5.40 and 4.60 m was probably deposited during a period with fluctuating lake levels, in consequence of which the rather shallow edges of the lake dried out regularly. Because of the low pollen sums and the fairly poor pollen preservation, spectra 10, 11 and 12 ought to be considered with reservation.

During subzone 3c time (spectra 14 and 15), human influence on the vegetation was probably negligible. The pollen evidence suggests that *Pinus brutia* forests prevailed on the slopes around the lake.

7.6.8. POLLEN ASSEMBLAGE ZONE 4 (SPECTRA 16-19)

This zone has already been discussed above (7.6.4.). It reflects fairly large-scale interference of man with the vegetation.

7.6.9. POLLEN ASSEMBLAGE ZONE 5 (SPECTRA 20-31)

Subzone 5a (spectra 20-26) is characterized by high *Artemisia* pollen percentages. During the period covered by subzone 5a, *Artemisia*-rich vegetations must have played an important part in the Köyceğiz area. We mentioned already (7.6.4.) that in the Eu-Mediterranean zone no modern analogue is found of an upland vegetation with predominantly *Artemisia* and that this vegetation type was probably induced by man. Other indications of human activity, such as *Vitis*, *Olea*, *Plantago lanceolata*-type and *Sanguisorba minor*-type, are scarce.

Subzone 5b (spectra 27-31) is distinguished from the previous subzone by the lower *Artemisia* pollen values. It seems that at the end of this subzone, spectrum 31, vegetations with predominantly *Artemisia* had completely been replaced by pine forest.

7.6.10. POLLEN ASSEMBLAGE ZONE 6 (SPECTRA 32-36)

In the lower part of zone 6 a decrease in *Pinus* and an increase in *Quercus* can be observed. *Artemisia* pollen values remain low in this zone (and in zone 7). The higher percentages for *Pteridium* and other ferns in samples 32 and 33 are indicative of open vegetations, while the Ericaceous pollen (spectra 33-36) points in the same direction. Other indications of human activity are present from spectrum 34 on: *Olea*, *Plantago lanceolata*-type, *Sanguisorba minor*-type. Continuous curves for *Olea* and *Vitis* start at the upper spectrum of zone 6.

7.6.11. POLLEN ASSEMBLAGE ZONE 7 (SPECTRA 37-46)

Zone 7 is distinguished from the preceding zone by the more frequent occurrence of pollen types which are indicative of human activity and by the fairly good representation of maquis species, such as *Pistacia*, *Myrtus* and *Paliurus*.

For samples 40 and 46, the ratio between both types of oak pollen was determined. The result indicates that of the *Quercus* pollen in the upper zone of the Köyceğiz diagram, ca. 3/4 is of the deciduous oak type. This implies that in spectra 38-46, *Quercus calliprinos*-type values varied from ca. 1.9 to 4.5%, and those of Q. *cerris/infectoria*-type from ca. 4.1 to 13.0%. In surface sample 14, at a short distance from the Köyceğiz coring site, the percentages for deciduous oak and kermes oak type pollen are 0.6 and 2.8% respectively (table 1). If one wants to compare these figures with those of the diagram, allowance must be made for the lower ΣAP value in the surface-sample spectrum. If one takes the ΣAP of the surface sample as 90%, which is about the average total tree pollen value in the diagram spectra 38-46, the values for Q. *cerris/infectoria*-type and Q. *calliprinos*-type amount to ca. 1 and 5% respectively. From the above we must conclude that quite recently, after the deposition of the sediment at a depth of 5 cm, deciduous oak decreased very considerably in the Köyceğiz area. It is reasonable to suppose that man was responsible for the strong decline in deciduous oak.

The low *Juniperus* pollen percentages in the upper part of the diagram are in agreement with the low values for this pollen type obtained in the surface samples from the lower Eu-Mediterranean zone (table 1).

The *Humulus/Cannabis* pollen in the upper three samples points to the cultivation of hemp or hop (*cf.* 7.5.9.) in the area. The marked decrease in *Olea* in the uppermost spectrum suggests a remarkable decline in olive cultivation in recent times. However, 2.0% *Olea* pollen in surface sample 14 indicates that this decline was only temporary. On the other hand, from the near-absence of *Vitis* pollen in surface sample 14 one must conclude that grape cultivation did not recover from the strong decline suggested by the upper spectra of the diagram.

7.6.12. SOME TREE POLLEN TYPES

Cedrus and *Abies*, which are both represented in the Köyceğiz diagram, are not likely to have occurred in the immediate vicinity of Lake Köyceğiz. At present, *Cedrus* grows in the mountains to the east of the lake, at elevations above 1,000 m. The nearest *Abies* stands are found in the Elmali area, more than 100 km east of Köyceğiz. The poor, irregular representation of *Abies* may probably be ascribed to the great distance of this tree from the coring site. The fluctuating *Cedrus* pollen values cannot easily be explained. One could imagine that the maxima represent periods in which cedar had recovered from large-scale cutting.

Pterocarya pollen was counted in a few samples. Although it is possible that the presence of this pollen is due to long-distance transport, one must consider the possibility that the *Pterocarya* pollen is of secondary origin. At least, the *Carya* pollen met with in some samples can only have been derived from older deposits.

The pollen of *Corylus*, *Tilia*, *Ostrya/Carpinus orientalis* and of a few other taxa probably originated from deciduous forests of the Oro-Mediterranean zone. It is not likely that *Betula* was found in the Köyceğiz area, but in the past, birch stands may have been less far away than at present (*cf.* 7.3.5.4. and 7.5.9.).

Of the swamp forest trees, *Alnus* shows the highest pollen values. *Ulmus* pollen was regularly found, although in low numbers. It is striking that *Liquidambar* and *Platanus* are best represented in the upper part of the diagram, suggesting that in more recent times suitable habitats for these trees expanded. *Datisca* (*cannabina*), a perennial herb, is to be expected in damp forests.

7.6.13. THE LOCAL VEGETATION

As for the local vegetation, it has already been mentioned that salt water enters the lake through the Dalyan river in the summer (7.6.1.). If in the past the influx of salt water had fluctuated, this must have affected the local vegetation which was under the direct influence of the lake water. A good indication of the local expansion of halophytic vegetations is most likely provided by high Chenopodiaceous pollen values. On the other hand, high pollen percentages for Gramineae, Cyperaceae and *Sparganium*-type must be indicative of predominantly fresh-water marsh vegetations.

The section covered by samples 16 to 21 remains a problem in that Chenopodiaceae as well as Gramineae and Cyperaceae show high values. Could this perhaps point to a fairly frequent alternation of brackish and fresh-water conditions? The presence of *Ruppia* pollen in samples 16, 17 and 18 indicates that the surface water was somewhat brackish.

Liguliflorae and Tubuliflorae Compositae and

Centaurea solstitialis-type reach fairly high percentages in various samples, which could be indicative of fluctuating lake levels.

In the period represented by the upper 1.40 m of the Köyceğiz core, predominantly fresh-water vegetations were found in the vicinity of the coring locality. The high percentages for Gramineae, Cyperaceae and *Sparganium*-type pollen from spectrum 34 onwards point to marsh vegetations bordering the lake. *Myriophyllum* and *Nymphaea* show relatively high values in the upper part of the clay deposit (samples 34-36), suggesting that the lake became more shallow. Finally, a marsh vegetation expanded over this part of the lake, giving rise to peat formation. The continuation of high values for *Nymphaea* in spectra 37 and 38, both from peat samples, points to open water at a short distance from the coring site.

The courses of the curves for *Nymphaea*, *Myriophyllum* and *Potamogeton* in the upper 50 cm of the diagram point to a rise of the lake level. This is also suggested by the fact that the upper 25 cm of the sediment consists of peaty clay, indicating a regular flooding of the marsh vegetation.

8. CONCLUSIONS

One of the aims of a palynological examination of sediment cores from a given area is the reconstruction of the regional vegetational and climatic history. The combined results should, among other things, make the drawing up of palaeo-vegetation maps for the area concerned possible.

Southwestern Turkey shows a large variation in topography (chapter 2) and climate (chapter 3). Consequently, the natural plant cover of the area is very diversified, ranging from ever-green Eu-Mediterranean vegetations in the coastal area to cold-tolerant coniferous forests in the mountains and xeric steppe vegetations towards the interior of Anatolia (chapter 4). Because of the complexity in the present-day natural vegetation pattern, a fairly large number of pollen diagrams, originating from different habitat zones, is required for the kind of reconstructions mentioned above.

It should be stated right away that the palynological evidence discussed in chapter 7 is absolutely insufficient for reconstructing the development of the vegetation of southwestern Turkey during the last 20,000 or more years. This, however, does not imply that no attempts should be made to compare the pollen diagrams from southwestern Turkey with each other and with palynological information from adjacent areas. As a first step towards establishing a regional vegetation history, the results for the individual sites need to be time-correlated. This has been attempted in table 8 which, for each of the diagrams, shows the type of vegetation in the successive periods. Because the dates for the pollen assemblage zones distinguished in each of the diagrams were mostly calculated, the correlations presented in table 8 are fairly conjectural. In particular, the correlation of zones 1-4 of the Karamik diagram with zones 1-3 of the Söğüt diagram meets serious difficulties as no radiocarbon date is available for the base of the latter diagram (see 7.5.3.).

The course of the ΣAP curve suggests two possible correlations for the lower part of the Karamik and Söğüt diagrams (table 7). The present authors are inclined to prefer the upper one of the two correlations presented in table 7. This preference is based upon the following consideration. The marked increase in ΣAP percentages in zone 2 of the Söğüt diagram is completely brought about by *Quercus*, pointing to rather dry climatic conditions. In zone 3 of the Karamik diagram, in a region which at present has less precipitation than the Söğüt area, cedar reaches high pollen values. Consequently, it seems that the climate inferred from zone 3 of the Karamik diagram was

TABLE 7. POSSIBLE CORRELATIONS OF THE LOWER PART OF THE KARAMIK AND SÖĞÜT POLLEN DIAGRAMS

Söğüt	Karamik
subzone 3c subzone 3b subzone 3a	zone 4 zone 3 zones 1 and 2
zone 3 zone 2 zone 1	zone 4 zone 3 zone 2, upper part

TABLE 8. TENTATIVE CORRELATIONS OF THE VEGETATIONAL HISTORY INFERRED FROM EACH OF THE DIAGRAMS DISCUSSED IN CHAPTER 7.

B.P.: 0, 1000, 2000, 3000, 4000, 5000, 6000, 7000, 8000, 9000, 10.000, 15.000, 20.000 | B.P.: 0, 1000, 2000, 3000, 4000, 5000, 6000, 7000

KARAMIK	
7	coniferous forest and some open vegetation (human influence)
6	coniferous forest with alternating cedar and pine dominance
5	transition from steppe and forest-steppe to coniferous forest
4	steppe and open forest stands
3	steppe, forest-steppe and cedar forest
2	steppe and open forest stands (predominantly cedar and oak)
1	steppe with some open forest stands

SÖĞÜT	
7	pine forest
6b	forest regeneration
6a	forest clearing
5	predominantly pine forest
4	forest (oak, juniper, pine); transition from steppe and forest-steppe to forest
3c	steppe with very scattered tree stands
3b	mosaic of steppe and forest stands (mainly oak and pine)
3a	predominantly steppe with tree stands
2b	less forest than in 2a
2a	mosaic of steppe and oak-forest stands
1	steppe with forest stands (conifers and deciduous trees)

BEYŞEHIR	
5	pine forest
4	forest clearing
3e	forest regeneration
3a-d	forest clearing
2	coniferous forest (pine and cedar)
1	coniferous forest (predominantly cedar)

HOYRAN	
7	forest and open vegetations
6	coniferous forest (pine and cedar)
5	forest and open vegetations
4	coniferous forest (pine and cedar)

KÖYCEĞIZ	
7	forest and maquis
6	forest (pine and oak)
5b	pine forest
5a	pine forest and Artemisia
1-4	forest (pine and oak)

distinctly moister than that of zone 2 of the Söğüt diagram. For that reason, it is less likely that zone 3 of the Karamik diagram would correspond with zone 2 of the Söğüt diagram. The correlation of zones 1 and 2 of the Karamik diagram with subzone 3a of the Söğüt diagram implies that the bottom part of the latter diagram is older than 20,000 years. We must admit that the above reasoning is weakened by the fact that in zone 4 of the Söğüt diagram oak pollen plays an important part, whereas in the largely corresponding zone of the Karamik diagram pine and cedar are the main tree pollen types.

Whatever the correct correlation between both diagrams may be, the pollen evidence suggests that in the period between 20,000 B.P. or older and ca. 14,000 B.P. steppe vegetations played an important part in the Söğüt and Karamik areas. In this connection it should be remembered that, in both areas, forests constitute the prevailing vegetation under natural conditions nowadays. Predominantly steppe vegetations during Full-glacial times are also suggested by other diagrams from the eastern Mediterranean area: Lake Ioannina (Bottema 1974), Lake Xinias (Bottema, in press), Tenaghi Philippon (Wijmstra 1969) and the Ghab (Niklewski & Van Zeist 1970). In the Lake Zeribar area, in western Iran, trees were completely absent in the period from ca. 22,000 to 14,000 B.P. (Van

Zeist 1967). The scarcity of trees during Full-glacial times in the eastern Mediterranean area is primarily ascribed to a dry climate. It is obvious that it was also much colder than at present, but the temperature would only have become a limiting factor for tree growth at higher elevations. One could wonder whether this was perhaps the case for Söğüt, at an elevation of ca. 1,400 m. However, this is not likely as, at the time, *Artemisia* steppes, and not alpine vegetations, prevailed in the Söğüt area.

The Full-glacial sections of the Karamik and Söğüt diagrams point to fluctuations in the proportion of trees in the upland vegetation. Similar fluctuations in the total tree pollen percentages can be observed in the other diagrams from the eastern Mediterranean area mentioned above. However, it seems doubtful whether these fluctuations can be used for a more detailed correlation of the diagrams. The climatic fluctuations to which the changes in vegetation must be ascribed certainly did not have the same effect on the vegetation everywhere.

From the Söğüt and Karamik diagrams one must conclude that, at least during the later phases of the Full-glacial, open vegetations prevailed in the greater part of southwestern Turkey. Unfortunately, the Köyceğiz diagram dates back to only ca. 5,000 B.P., so that no information is available on the Full-glacial vegetation in the coastal area of southwestern Turkey. One may assume that coastal areas which at present receive much precipitation (1,000 mm and more) supported forest vegetations in Full-glacial times.

Zone 3 of the Karamik diagram and probably also subzone 3b of the Söğüt diagram coincide with the first half of the Late-glacial of western and central Europe. During the greater part of the Late-glacial, forests expanded over Europe north of the Alps, which was due to an increase in temperature and humidity. Only during the final phase of the Late-glacial, during the Younger Dryas-time, climatic conditions became less favourable for tree growth. For a discussion of Late-glacial vegetation and climate in the Eastern Mediterranean the reader is referred to Bottema (in press).

The pollen evidence for Karamik and Söğüt indicates that in the areas concerned conditions became more favourable for tree growth after ca. 14,000 B.P. This points to an increase in humidity. One may expect that in Turkey, too, the temperature rose in Late-glacial times. Apparently, in the mountains of southwestern Turkey, the effect of increased evaporation, which resulted from the higher temperatures, was more than compensated for by the increase in precipitation. This was not so everywhere. Thus, the diagrams from Lake Xinias in East-Central Greece (Bottema, in press) and from the Ghab valley in Northwest Syria (Niklewski & Van Zeist 1970) indicate that at lower elevations, conditions for tree growth became extremely adverse in Late-glacial times, most probably as a result of a further increase in dryness.

One may assume that in southwestern Turkey, trees started to expand after 14,000 B.P., although steppe vegetations continued to play an important part. The nature of the forest vegetations in the mountains must have shown considerable differences, depending on topography, climate and perhaps other factors. Thus, in the Karamik area cedar prevailed, whereas pine and oak were the most important trees in the Söğüt area.

Between 12,000 and 11,500 B.P. conditions again became unfavourable for tree growth (zone 4 at Karamik, subzone 3c at Söğüt). In this connection it should be mentioned that, in Europe north of the Alps, it was established that in the Allerød-time (ca. 12,000-11,000 B.P.) mean July temperatures had reached a level which was only 2°C lower than at present. Consequently, it seems likely that in southwestern Turkey the increase in dryness, suggested by the marked decline in tree growth, was the result of a further rise in temperature. The drop in temperature after ca. 11,000 B.P. (Younger Dryas-time) is not reflected in the pollen record of Karamik and Söğüt.

The pollen evidence from central and western Europe, and also from other parts of the world, clearly points to a considerable rise in temperature during the first stages of the Postglacial, after ca. 10,000 B.P. or a little earlier. At the same time precipitation increased. At Karamik no possible reaction of the vegetation to this change in climate is reflected in the pollen record of the upper part of zone 4. Apparently, dryness remained the limiting factor for tree growth. At Söğüt a slight increase in tree pollen percentages can be observed in the upper part of subzone 3c, suggesting a minor expansion of trees after ca. 10,000 B.P. At the beginning of the Postglacial, steppe vegetations must still have prevailed in the greater part of southwestern Turkey.

Forest vegetations expanded more considerably after ca. 8,500 B.P. Pollen zone 5 at Karamik reflects the transition from the steppe and forest-steppe vegetations of zone 4 to the coniferous forest cover of zone 6. During zone 5 time, conditions for tree growth became more favourable in the Karamik area, undoubtedly as the result of an increase in humidity. The Karamik diagram suggests that at the end of zone 5, about 6,000 B.P., humidity had approximately reached modern levels. Zone 4 of the Söğüt diagram provides a similar picture to that at Karamik. In the Söğüt area ca. 3,000 years elapsed before the steppe vegetations had been replaced by forests.

From the pollen evidence for Karamik and Söğüt one may conclude that during the first half of the Postglacial, from ca. 10,000 to 6,000 B.P., the climate of southwestern Turkey was drier than in the second half of this period. Palynological data from adjacent areas point in the same direction. Thus, in the Lake Zeribar area, in the mountains of western Iran, the steppe-forest evolved into a mixed-oak forest after 6,000 B.P., suggesting that it was not until that date that humidity increased to modern levels (Van Zeist 1967). On the grounds of a detailed palynological study in the north of Greece, Bottema (1974) arrived at the conclusion that in the beginning of the Postglacial, up to ca. 8,300 B.P., the climate was dry. Thereafter, precipitation would have increased, but it was not until ca. 6,500 B.P. that the humidity reached the present-day level.

Thus, the palynological evidence from various areas in the Eastern Mediterranean indicates that in early Postglacial times the climate was drier than at present. As has already been suggested elsewhere (Van Zeist 1969), this "greater dryness" may not necessarily imply less precipitation. It is feasible that, as a result of higher temperatures or of a longer rainless period, the summers were drier. A greater summer dryness would have affected tree growth in particular.

The available palynological data do not provide any clues for the reconstruction of the vegetation pattern of the present-day Oro-Mediterranean belt of southwestern Turkey during the period of ca. 8,000 to 5,500 B.P. Besides pine, deciduous oak and juniper played an important part in the woodland vegetation of the Söğüt area in the period under consideration. On the other hand, in the Karamik area hardly any deciduous oak and juniper were found at that time, but here the forest and steppe-forest stands consisted mainly of cedar and pine. In view of the fact that the climate of the Karamik area is drier than that of Söğüt, this behaviour of juniper and deciduous oak is contrary to expectation. Thus, the factors determining the distribution of deciduous oak, juniper, pine and cedar in the mountains of southwestern Turkey in the period of ca. 8,000 to 5,500 B.P. are not yet clear. For that reason, it is better to confine oneself to the conclusion that, in the period concerned, forests gradually took possession of the area of the present-day Oro-Mediterranean belt.

The Karamik and Beyşehir diagrams suggest that in the areas covered by both diagrams, the present-day natural vegetation pattern became established, in broad outline, shortly after 6,000 B.P. At Söğüt, on the other hand, it was not until ca. 3,000 B.P. that pine forest became the dominant vegetation. The establishment of the present-day natural vegetation pattern in the mountains of southwestern Turkey was not a synchronous phenomenon over the whole of the area. It was not simply a moving up or down of vegetation zones.

The Köyceğiz diagram suggests that about 5,000 years ago the present-day natural vegetation occurred in the coastal area and that since that time no climatic changes are suggested by the vegetation. All the changes in the upland vegetation reflected in the Köyceğiz pollen record must be ascribed to human influence. In all probability, from the development of the vegetation in the mountains of southwestern Turkey, no conclusions can be drawn on the character of the vegetation in the adjacent coastal area prior to 5,000 B.P. At least no clue for such a correlation presents itself from a comparison of the Postglacial vegetation history of Mljet on the Dalmatian coast (Beug 1967) with that of the interior of Greece (Bottema 1974).

The conclusion that the present-day natural vegetation pattern in the Karamik-Beyşehir and Söğüt areas became, in broad outline, established ca. 6,000 and 3,000 B.P., respectively, does not imply that since then no more changes in the vegetation took place. Thus, zones 6 and 7 of the Karamik diagram reflect an alternating dominance of pine and cedar. The Beyşehir diagram indicates that the proportion of cedar in the forest cover of the area diminished further after 5,800 B.P. At Söğüt, deciduous oak and juniper continued to decrease after 3,000 B.P., so that in the forest vegetations of the last 1,500 years these trees played only an insignificant part.

The Söğüt diagram suggests a further increase in humidity between ca. 6,000 and 1,500 B.P., which would seem to imply that the climate of the last 1,500 years was moister than ever before in the Postglacial. The Karamik diagram, on the other hand, does not provide indications of a lasting increase in humidity after 6,000 B.P. It has already been set forth (7.3.8.) that for the time being it cannot be determined whether the replacement of cedar by pine in the Beyşehir area must be considered as evidence of an increase or of a decrease in humidity.

The changes in climate inferred from the Karamik and Söğüt diagrams for the period of ca. 20,000 to 6,000 B.P. correspond rather well with each other. However, for the period after 6,000 B.P. the palynological evidence for both sites does not seem to point to an identical climatic history.

9. SUMMARY

In this paper the palynological examination of surface samples and sediment cores from southwestern Turkey is discussed. The main objective of this study is the reconstruction of vegetation and climate in Late Quaternary times.

The geology, climate and natural vegetation of southwestern Turkey are briefly reviewed in chapters 2, 3 and 4. A tentative reconstruction of the distribution of the major vegetation units is presented in fig. 6.

Altogether 59 surface samples, originating from natural and more or less seriously degraded vegetations, were examined (*cf.* fig. 10). The results of the surface-sample study are shown in tables 1-5. Table 6, in which for a selected number of pollen types, mean percentages per sub-group are given, should facilitate a comparison of the pollen precipitation in the various vegetation types. *Pinus* is, again, over-represented in the pollen rain. The share of deciduous oak, *Quercus calliprinos*, *Cedrus*, *Juniperus*, *Phillyrea*, *Pistacia* and *Olea* in the pollen precipitation corresponds rather well with that in the vegetation. Striking are the rather low *Abies* pollen values in the samples from a fir forest. High *Plantago lanceolata*-type pollen values were obtained for areas with serious grazing, but, on the other hand, grazing does not necessarily lead to an expansion of plantain.

A survey of the results obtained for the sediment cores from Karamik Batakliği, Beyşehir Gölü, Hoyran Gölü, Söğüt Gölü and Köyceğiz Gölü (*cf.* fig. 10) is presented in table 8. The diagrams of Karamik and Söğüt suggest that in the period of ca. 20,000 to 10,000 B.P., open vegetations prevailed, implying that the climate was rather dry. *Artemisia* played an important part in the Full-glacial and Late-glacial steppe vegetations. During somewhat moister phases, more or less open forest stands, consisting of pine, cedar and deciduous oak, could expand to some extent.

Open vegetations prevailed during the first stages of the Postglacial, too. After ca. 8,500 B.P. forest vegetations started to expand in the mountains of southwestern Turkey. About 6,000-5,500 B.P. forests must entirely have taken possession of the present-day Oro-Mediterranean belt (ca. 800-2,000 m). The establishment of the present-day natural vegetation pattern was not a synchronous phenomenon over the whole of southwestern Turkey (*cf.* Karamik and Söğüt). The pollen evidence suggests that during the first half of the Postglacial, from ca. 10,000 to 6,000 B.P., the climate of southwestern Turkey was drier than later on.

The Söğüt and Beyşehir diagrams reflect large-scale interference of man with the vegetation in the second and first millennia B.C. The forest must have been cleared over large areas. As for palynological indications of grain-growing, various Near Eastern wild grass species produce Cerealia-type pollen grains. Fruit trees cultivated by the Beyşehir and Söğüt farmers included: *Juglans* (walnut), *Castanea* (sweet chestnut), *Olea* (olive) and *Vitis* (grape). Besides, *Fraxinus ornus* (manna ash) was planted, most probably for its manna.

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