Recent Dynamics of the Mediterranean Vegetation and Landscape

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Preface

The ideas behind this book arose from the work undertaken as part of the ModMED research project under the auspices of the Environment Programme of the European commission[1]. As part of this project, the development of the vegetation landscape in recent decades was analysed using aerial photo-interpretation at sites in Italy, Greece and Portugal. These studies showed major expansion of shrubland and forests in previously cultivated and grazed areas *in contrast* with the widely assumed ongoing climate-driven desertification in the Mediterranean area. In order to test this conclusion in a larger number of sites around the Mediterranean basin, more than half of the chapters of this book were commissioned to scientists outside the original ModMED team.

The Mediterranean region has been shaped by human activity and maintained by traditional practices of land use for centuries or millennia. This has affected the distribution of plants and the landscape, which can be considered as part of the European cultural heritage. This book is about the rapid changes that have taken place in the vegetation of the Mediterranean in the last half-century, a period in which major socio-economic development greatly affected the ancient, traditional landscape and, in a broader sense, the cultural environment and the human perception of nature. The book develops a view that contradicts the generally held notion of traditional land management as being in balance with nature for millennia until the imbalance of recent decades, which is apparently leading to catastrophic desertification. The view held here is closer to the reverse in which recent decades have allowed a major recovery of the ecological system throughout the Mediterranean basin.

The book is aimed at a spatial scale *in between* the traditional broad-scale characterisations and the detailed small-area studies. The timescale of the studies (analysis of change over 50 years) bridges historical and contemporary studies and is focused on *observed* vegetation change within its socio-economic and cultural context *across* the Mediterranean. Previous works have tended to concentrate on one or a few sites in great detail (such as the classical studies of Rackham) or, on the other hand, on the Mediterranean scale in a very generalised way through mapping or remote sensing. The approach of this book is to bridge these scales to provide a Mediterranean-wide view, but through detailed research on land use and cover at a variety of sites.

Descriptions and explanations of observed changes of vegetation types and cover are given without reverting to some long-term global change but within the context of the dynamics of agricultural, ecological and socio-economic context of the countries reviewed. The collection of chapters gives a good overall picture of what is happening around the Mediterranean basin in terms of vegetation landscape dynamics and concludes that land abandonment has triggered major recovery of woodlands, whereas under traditional land use the vegetation is either stable or degrading. As mentioned before, the evidence arising from this picture is that local land use and not global change is the driving factor for observed changes in the Mediterranean and that indeed there is no evidence for a Mediterranean-wide desertification process.

The initial section of the volume provides a background of the vegetational state and history in the Mediterranean region, whereas the final contributions discuss the interactions between climate and land-use changes in terms of vegetation effects. The chapters are not diluted by long-winded discussions of methodology but focus in a clear, standardised form on providing the empirical data and on the analysis and interpretation required to develop the conclusions. The message from the book will be of interest to those studying vegetational history and dynamics as well as to those in the global change research community and also to the practitioners of land use and landscape planning. For example, the conservation of biodiversity and the increasing problem of wildfire in the Mediterranean

[1]ModMED I and II (Modelling Vegetation Dynamics and Degradation in Mediterranean Ecosystems), EV5V-**CT94**-0489, ModMED III (Modelling Mediterranean Ecosystems Dynamics). Scientific Officer Denis Peter, DGXII/D2-ENV4-CT97

region can be better managed by understanding the interactions of landscape and land use with land-cover changes in different national and local contexts.

Though this book is focused on the European Mediterranean area, there will be lessons that will be of value to practitioners and academics working in Mediterranean environments throughout the world. Vegetation scientists will find many case studies of change and its drivers, the global change community will discover something of the resilience and the variability of the Mediterranean vegetation and practitioners will see some of the results of past land-use strategies, positive and negative.

In the end, the value of this book reflects the efforts of the contributors who the editors would like to congratulate for producing excellent chapters within the limits of time and space that were set. An early draft of the book benefited from the comments of three anonymous reviewers to whom we are grateful. Sophia Burke is thanked for carrying out a thorough revision of the English language. We are also grateful to Antonello Migliozzi for his assistance in the editing of figures. Finally Sally Wilkinson and, later Keily Larkins and Susan Barclay from John Wiley are acknowledged for helping us see the volume through to a successful end.

Stefano Mazzoleni

Part I

OVERVIEW OF THE MEDITERRANEAN BASIN

1

Large-scale Post-glacial Distribution of Vegetation Structures in the Mediterranean Region

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1.1 INTRODUCTION

1.1.1 The Mediterranean vegetation

Several studies have considered the history and definition of Mediterranean flora and vegetation in the northern part of the Old World (Walter and Straka, 1970; Axelrod and Raven, 1978; Pignatti, 1978; Quézel, 1995). From a strictly biogeographical standpoint (Quézel, 1978, 1985; Quézel *et al.,* 1980), today's Mediterranean flora has several heterogeneous groups connected to the region's palaeohistory. The circum-Mediterranean region is situated where Laurasia merged with the last traces of Gondwana and its floristic composition comprises elements of southern (tropical) origin and elements of autochthonous and northern (extra-tropical) origins. The survival of islands since at least the Cretacean period (Biju-Duval *et al*., 1976) permitted numerous exchanges between the two origins and the development of a rich endemic flora favoured by the extreme heterogeneity of the substrata, geomorphology and the climate. Currently, the circum-Mediterranean region contains some 25,000 plant species, of which roughly half are endemic.

Several summaries of the historical data exist (Medus and Pons, 1980; Bazile-Robert *et al*., 1980; Pons, 1984; Quézel and Médail 2003) and indicate that the earliest occurrences of this flora were found in the lower Cretacean era. In spite of the innumerable taxonomic uncertainties, they increased in number during the Eocene and especially the Oligocene; however, the floras of Saint-Zacharie (Saporta, 1866) and Aix (Saporta, 1872) were still limited. In the Miocene, and even more so in the Pliocene, numerous Mediterranean elements began to make their appearance (*Cedrus, Abies, Pinus* ssp., *Quercus* cf. *ilex, Olea, Myrtus, Phillyrea, Cistus,* etc.) (Suc and Cravatte, 1982; Suc *et al*., 1984; Drivalliari, 1993 for the eastern Mediterranean), which are associated with a large number of other taxa, which are exotic today, but which nonetheless form a true Mediterranean vegetation, albeit localised and episodic.

From the palaeoclimatic point of view, Suc, (1984) relates the first occurrence of a phase of summer drought with the first arctic glacial extension in the northern Mediterranean region, at about 3.2 Mybp. Thereafter were successive phases of greater aridity in relation to the glaciations of the Pleistocene. "Each cold period is matched by a diminution in precipitation which in turn causes summer drought marked by clear seasonal contrasts, while each period of warming is characterised by an increase in precipitation which cancels out the summer drought" (Suc, 1980).

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1.2 THE LARGE-SCALE VEGETATION STRUCTURES

Throughout the Mediterranean area, the current organisation of vegetation structures is the direct consequence of the climatic modifications since the last glacial withdrawal. However, in addition to this natural phenomenon, the region has also seen the explosion of Neolithic civilisations of herders and farmers, which had a profound influence on the natural ecological equilibrium brought about by gradual climatic warming over more than 10 millennia (Reille, 1975; Triat, 1979). Thus, in spite of the difficulties involved, we should attempt to establish what part was played by each of the two processes. It is now clear that while natural influences were predominant up to the Atlantic period, anthropic influence was more or less predominant thereafter, with a time lag running from east to west across the basin (Bottema and Van Zeist, 1981).

If we exclude azonal vegetation structures, which are virtually unaffected by local climatic influences and which, therefore, will be merely mentioned briefly here, the classic vegetation series in the Mediterranean region have certain fundamental structures whose physiognomic similarity in terms of landscape ties in with ecological and dynamic criteria valid over space and time (Figure 1.1).

1.2.1 Pre-steppe-forests

Pre-steppe-forests (Abi-Saleh *et al*., 1976) are loose forests whose understorey is made of shrubs and subshrubs with no precise syntaxonomic value with respect to the tree species present. The description of this type of landscape has become important following the ecological and phytosociological study of the scrublands currently found throughout the Maghreb and Eastern Mediterranean in more semiarid or even arid climates, and also in other types of bioclimate with severe winter thermal values (*in sensu* Emberger, 1939) of less than $-3\,^{\circ}$C. This occurs in the mountain belt and particularly in the oro-Mediterranean belt (Quézel, 1974), where the high altitude forest species that originated in the

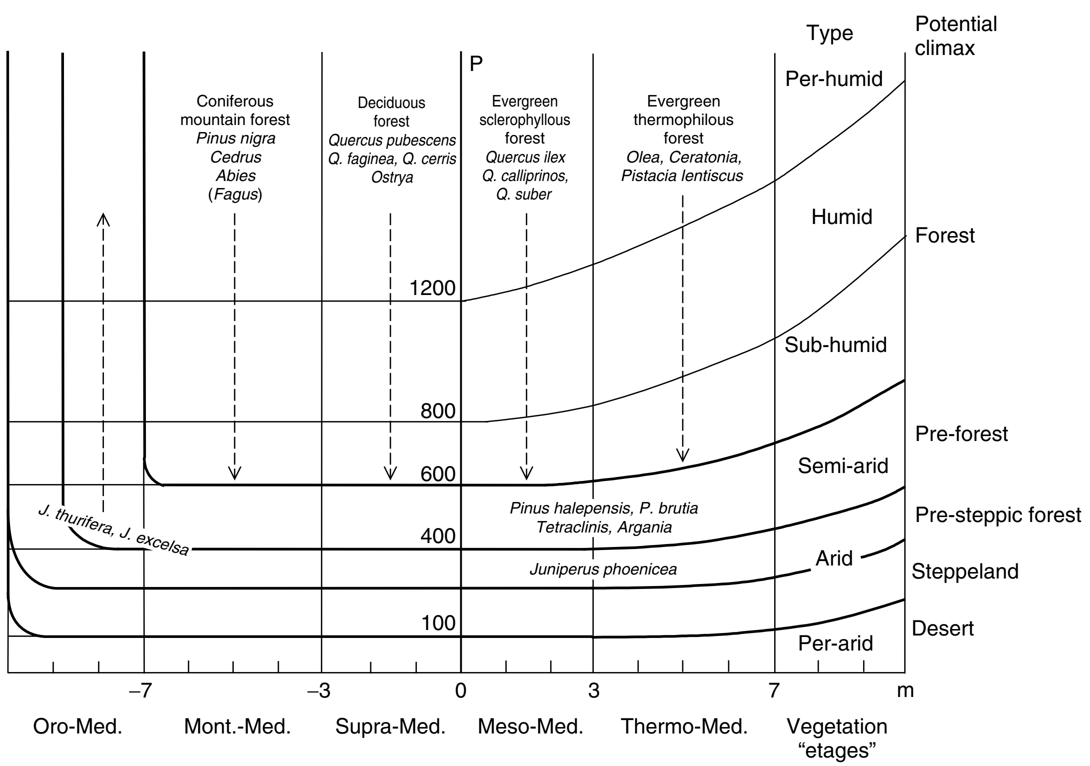

Figure 1.1 Schematic representation of the major types of vegetation structure around the Mediterranean, according to the bioclimatic types and "étages" of vegetation. p refers to annual mean rainfall; m refers to means temperature of the coolest month. Only a few species are indicated (after Quézel, 1985 © CNRS)

north have not been able to take root for primarily historical reasons.

This type of landscape occupies large areas of these regions mentioned above, but it can also occur in limited areas throughout the Mediterranean basin as a result of both edapho-climatic parameters and intensive anthropic activity. It is made up primarily of conifers (*Pinus, Tetraclinis* and above all *Juniperus*) or, less commonly, of sclerophyllous oaks, often with considerably less than 50% cover, that develop on low scrublands where some matorral species may survive, but where Gramineae and Therophytes predominate. A distinction has been made between steppe- and pre-steppe-forests that are xeric in nature, and so are subject to insufficient precipitation (hydric stress), and those that are thermic in nature, and so are subject to severe winter temperatures (thermic stress) (Quézel *et al*., 1980).

These vegetation structures raise interesting questions when one tries to place them in a historical and dynamic context. As illustrated elsewhere (Quézel *et al*., 1980), on the one hand these pre-steppe-forests enable us to understand, or at least imagine, which types of vegetation played a fundamental role in the Mediterranean region during the Holocene, and on the other hand they account for recent phenomena of steppe formation due to anthropic action round the southern and eastern rims of the Mediterranean basin.

From the historical point of view, while restricting ourselves to the Würmian and post-Würmian periods (Pons and Quézel, 1985, 1998) (Figure 1.2) for which there is considerable documentation, and bearing in mind that cases of analogous or at least similar structures appeared during previous glacial phases, nonetheless, there are striking parallels between the published

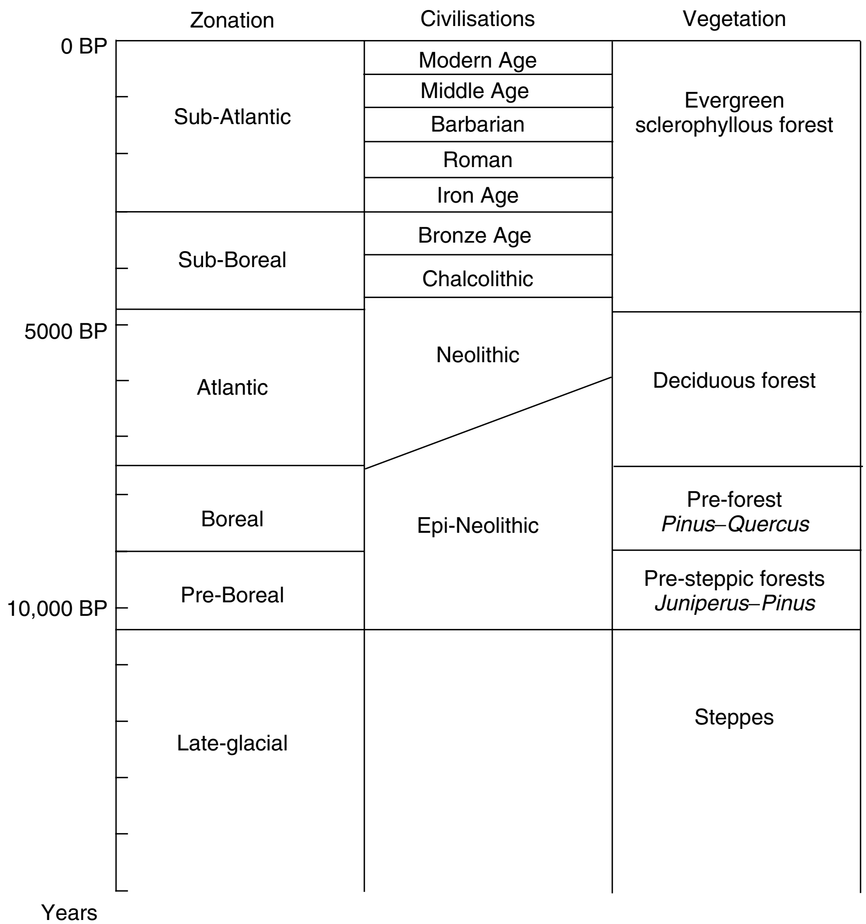

Figure 1.2 Diagram showing the different geological zonations, civilisations and vegetation types during the Holocene in Southern France

findings of palynologists and palaeoanthrapologist and the data we have referred to above. In the territories now in the southern Mediterranean, the Würmian vegetation comprised in general of wooded steppe featuring *Pinus* with *Poaceae, Artemisia, Chenopodiaceae* and *Ephedraceae* in particular (Pons and Reille, 1988; Bernard and Reille, 1987). *Juniperus* and then sclerophyllous oak become predominant from the end of the ancient Dryas, that is, a little over 12,000 BP

Findings in southern France are similar (Vernet, 1973, 1985; Beug, 1975; Reille, 1975; Triat-Laval, 1978–79), although here genuine forest structures appeared several millennia later (cf. *infra*). These studies confirm the existence of steppe-forest virtually throughout the whole of the western Mediterranean basin, and its floristic composition reflects, fairly accurately, the vegetation structures of the pre-steppe-forests we know today, which are areas invariably colonised by classic Mediterranean forests. However, this does not apply to the eastern Mediterranean (Van Zeist and Bottema, 1982) where, as is now the case in the Irano-Turanian region (Quézel and Barbero, 1985), the arboreal element has had a less prominent and above all a more delayed role to play, with a clear preponderance of sclerophyllous oaks and even of *Cedrus* in the coastal zone. Unfortunately, palynologists and indeed even palaeoanthrapologist are all too often unable to identify *Juniperus* and *Pinus* genera remains at the species level, and this is a considerable constraint on the interpretation of findings and the comparison with the current vegetation structures. Anyway, it is very reasonable to believe that the Würmian and late-Würmian pre-steppe-forests in the Mediterranean basin were variable due to concomitant ecological criteria, in much the same way as those still existing: thermic pre-steppe-forests of *Juniperus thurifera* in the west and *Juniperus excelsa* in the east, and *Juniperus hemispherica* was present locally, geographically associated with various *Pinus* and above all *Pinus sylvestris* (in its Mediterranean forms) in Mediterranean Europe. The xeric pre-steppe-forests, on the other hand, have by and large remained confined to the southern reaches of the Mediterranean. Their principal arboreal constituents are represented by *Juniperus phoenicea* and *Pinus halepensis* in the continental zone, and *Tetraclinis*, *Argania spinosa* and *Acacia gummifera* in the oceanic zone. The current distribution of *P. halepensis* and *J. phoenicea*, and of *Pistacia atlas* in the southern Mediterranean, gives a good picture of the distribution of these continental steppe-forests, because these species are also to be found in a sporadic fashion from the Moroccan Atlas right across to Jordan. On the contrary, *Argania* and *A. gummifera* provide important indicators as to the distribution of xeric steppe-forests, but with an Atlantic aspect, when the influence of the cold phases of the Quaternary was significantly attenuated so as to permit the local survival of tropical species with a xerophile origin, which can also be found in the Canaries. Their most visible, if not significant, elements are succulent spurges (Quézel, 1978), and recently a *Dracaena* was discovered (Benabid and Cuzin, 1997). It is well to recall that this steppe-forest advanced a long way south during the climatic optimum in the Sahara and, in particular, reached the mountains of the central Sahara (Pons and Quézel, 1958).

1.2.2 Pre-forestal structures

This essentially dynamic concept (Rivas-Martinez, 1975) applies to structures with the physiognomy of a forest whose evolution in both floristic and edaphic (dynamic) terms is still ongoing. In theory, the pre-forests correspond to transitory stages, and they constitute ecotones, which, in the classic dynamic model of the constitution of forests in the Mediterranean region, lie between matorrals and forests. However, this theoretical scheme ignores long-lasting disturbances such as the reconstitution of the forest cover of the Mediterranean at the beginning of the Holocene, when pre-forests represented important stages in the reconstitution of the forest locally, as a result of natural disturbances, and, in particular, fires and extreme gusts of wind.

This situation changed drastically throughout the Mediterranean basin following the appearance of humans and the progressive intensification of forest use. Over a period of a few millennia, forests were very frequently replaced by pre-forest type structures as a result of direct use and of grazing. This seems to be the only explanation for the increase in coniferous pollen contemporaneous with and following anthropic action in a humid and subhumid bioclimate zone, involving the two species *Pinus pinaster* in the High Atlas (Reille, 1976) and *P. halepensis* in Provence (Triat-Laval, 1978) and in Dalmatia (Beug, 1961, 1967). These phenomena occurred right up until the present age, as demonstrated not only by the palynological evidence (Pons, 1984), but also by phytosociological analysis of the vegetation structures. In fact, in the first decades of the last century, virtually all the arboreal structures of the thermo- and meso-Mediterranean belts were considered to be, in effect, pre-forestal scrublands. In a humid or subhumid bioclimate, this was normal for the paraclimacic coniferous structures (*P. halepensis, P. brutia, P. pinaster*, and also *Cupressus sempervirens* in the eastern Mediterranean) but not for the sclerophyllous oak (cfr. *infra*).

With reference to the pre-forestal grouping, we should also mention scrublands that comprise a variety of thermophilous evergreen species, in particular *Ceratonia siliqua*, *Olea europaea* and *Pistacia lentiscus*. Unfortunately, we lack the historical data for a clear idea of the role played by these species in the Holocene. The investigations that have been carried out reveal a limited development of *Olea* and *Pistacia* from the recent Dryas onwards in the western Mediterranean (but would they give the same results in the Maghreb?). This was observed in Padul (Pons and Reille, 1988) when *Pistacia* shows a greater precocity, and in the Marrakesh Atlas, in both cases before human action began (unlike what happened in southern France). *Ceratonia*, a weak pollen producer, is absent. In the eastern Mediterranean, *Olea* and *Pistacia* are more common, and are also present in the stands currently in the termo-Mediterranean from the late Würmian period; *Ceratonia* has not been observed (van Zeist and Bottema, 1982). Thus, it would seem that these species, regardless of their clear increase due to human activity, have only played a marginal role in the constitution of termo-Mediterranean landscapes; the structures made up of *O. europaea* subsp. *sylvestris* that occur in a sub-rupicola position in the Taurus (Akman *et al.*, 1978) give an indication of this. However, the existence of "Marabout" in forestal zones (Benabid, 1984), in the Rif, in particular, demonstrate that this tree species, in connection with those already mentioned in this section, is able to achieve real forestal structures on deep soils, as indeed Emberger, 1939 hypothesised for other regions in Morocco.

In the present semiarid bioclimates and the thermo- and meso- Mediterranean belts, *P. halepensis* in the Maghreb, *Pinus brutia* in the eastern Mediterranean (Quézel and Barbero, 1985) and also *Tetraclinis articulata*, and indeed *Olea* and *Ceratonia* constitute pre-forestal groupings over vast areas, which, in current conditions (Barbero *et al.*, 1988a,b), represent genuine climax scrublands, since they are not able to evolve towards mature structures of sclerophyllous oaks. In a continental environment as in the Maghreb, a vast belt of pre-forestal-type vegetation formed, which, where it has not been destroyed by humans, can be situated between the pre-steppe-scrublands illustrated above and the sclerophyllous oak forests (Kadik, 1983; Fennane, 1987).

Similar situations may appear in a humid or subhumid bioclimate due to the nature of the substratum. In particular, this is true of the ultrabasic substrata, which occupy large areas in Greece and Turkey, where the natural maturation seems unable to go beyond the pre-forestal state. In southern Anatolia, the scrublands of *P. brutia* (Akman *et al.*, 1978–79) indicate very unusual groupings in which the presence of sclerophyllous oaks (*Quercus calliprinos*) is practically impossible to affirm; in the western Mediterranean, the same is true for the scrublands of *P. pinaster* on dolerite in the region of Malaga. The marnous or dolomitic substrata can produce similar situations even if the block appears less homogeneous. This can be observed in particular in Southern Anatolia (Akman *et al.*, 1978) and Lebanon (Abi-Saleh, 1978), which have scrublands of *P. brutia* and *C. sempervirens* on marne or on dolomite; in scrublands of *Pinus nigra* subsp. *salzmannii* in the region of Saint Guilhem du Désert (Braun-Blanquet, 1955; Quézel and Barbero, 1988a,b), in *Pinus pinea* on sand and sandstone, particularly in Lebanon (Abi-Saleh *et al.*, 1976) and Anatolia (Akman *et al.*, 1978). On compact limestone in a sub-rupicolous position, pre-forestal structures of sclerophyllous oaks and *Juniperus* can be found scattered throughout the Mediterranean, undoubtedly the most famous being the series of *Quercus ilex* and *J. phoenicea* (Ozenda, 1975) in southern France. This represents a real edaphic climax whose further evolution towards a forest stage is prevented by the site slope.

However, apart from the situation described above, the forestal species that make up the pre-forestal and, particularly, the pre-steppe systems have an evident expansionist strategy (Barbero *et al.*, 1988a,b; Barbero *et al.*, 1990). These are the same species that are currently taking over in abandoned areas, on post-cultivation terrain, and also following fires in a humid or subhumid bioclimate, and constitute paraclimacic pre-forestal structures whose eventual maturation, in the absence of any disturbance, points to the secondary installation of oaks.

1.2.3 Forests

The development of true forestal structures, in the sense commonly accepted by ecologists and phytosociologists, that is, stable climax-type scrublands, with an evolved soil and a significant floristic composition, is a relatively recent phenomenon in the Mediterranean basin, dating at the earliest from the end of the Würmian period. Mediterranean forests can be classified into three main types: sclerophyllous forests, broadleaved forests and coniferous forests (chiefly on mountainous terrain). The occasional presence in this sector of elements of laurisylva (*Laurus, Ilex, Taxus*) represents a level of maturation and non-disturbance, which is now rarely achieved. (Barbero and Quézel, 1994).

1.2.3.1 Sclerophyllous forests

Classically these represent the typical Mediterranean forests and many authors following Flahault (1937) have sought to define and delimit the Mediterranean region by means of their presence. In fact, the situation is infinitely more complex. While they are generally predominant in the meso-Mediterranean belt (*Quercus ilex, Q. rotundifolia, Q. suber* in the western Mediterranean, *Q. calliprinos* in the east and *Q. alnifolia* in Cyprus), they are perfectly capable of spreading into the thermo-Mediterranean given favourable ecological conditions (Barbero *et al*., 1981), and indeed into the upper belts especially in northern Africa where *Quercus rotundifolia* in the western High Atlas, constitute the upper forest limit at about 3000 m (Emberger, 1939).

From a historical point of view, sclerophyllous species have existed in the Mediterranean basin since at least the Miocene (Suc, 1984), but their role has undergone many changes. If we consider only the last glacial cycle, documentation currently available (Reille *et al*., 1999) shows that during the Würmian glaciation, their role was minor or even non-existent at a local level in places where such species now predominate. They did not have a synchronous extension throughout the Mediterranean. In France, for example, sclerophyllous oak stands appear only progressively after the installation of broadleaved oak stands from 8000 BP onwards, and eventually became omnipresent in the Atlantic. Further south, at Padul in Andalusia (Pons and Reille, 1988), the rise of sclerophyllous and broadleaved oaks came about practically at the same time, from the end of the ancient Dryas (12,500 BP), the former only gaining the upper hand in around 6000 BP. In northern Africa, where we still do not have a long series, in the 'daya' of Tighaslant in the Marrakesh Atlas (Bernard and Reille, 1987), *Quercus canariensis* and *Q. rotundifolia* are abundantly present from the beginning of the Boreal era, with the former predominating up to the end of the Atlantic and then declining until they practically disappeared in the sub-Boreal. In the eastern Mediterranean (Van Zeist and Woldring, 1980; Bottema and Van Zeist, 1982), broadleaved (*Q*. cf. *cerris*) and sclerophyllous oaks (*Q. calliprinos*) are present in the meso-Mediterranean belt from the end of the Würm, in northern Syria in particular. In fact, the authors agree in all these cases that there is a correlation between the extension of sclerophyllous oak and the development of anthropic activity. Although we still have insufficient data, in particular for the Maghreb, it seems clear that in the northern Mediterranean and indeed on the north African coast, it was human activity rather than climate change that caused the extension of the sclerophyllous oaks. The palynological data (Reille *et al*., 1980) confirm the initial extension of *Q. ilex* in the pre-forestal type structures with *Juniperus* and *Pinus*, while its appearance in the broadleaved oak stands occurring in the valleys coincides exactly with the opening up or their destruction at the hands of humans.

This matches the inverse phenomenon, which nowadays can be widely observed in Southern France (Quézel and Barbero, 1988a,b) and other regions; after about half a century of disuse, the sclerophyllous forests transform, the floristic composition is modified through the elimination of the specifically pre-forestal elements and new groupings appear, which seem not to have existed at the time the studies were carried out by Braun-Blanquet (1936). In these conditions, the French climacic holly oak forest (*Quercetum ilicis gallo-provinciale*) defined by this author would simply be a meta-stable stage corresponding to the traditional conditions of human use of these forests over the last centuries. The current disuse allows a massive resurgence of *Quercus pubescens* in the *Q. ilex* stands as well as the identification of new climax groupings in which the floristic composition tends to model itself increasingly on the broadleaved oak stands on account of the increase in hemicriptophytes and geophytes, in particular, which constitutes a favourable tendency for the reconstitution of the herbaceous resources used for grazing.

1.2.3.2 Broadleaved forests

Broadleaved forests present a high degree of variability in the Mediterranean basin (Quézel, 1974; Quézel and Bonin, 1980). They have traditionally been considered by phytoecologists as the defining paradigm of the supra-Mediterranean belt (Ozenda, 1975), constituted by various species of oak (Quézel and Bonin, 1980). However, analysis of vegetation structures on a circum-Mediterranean scale reveals that their current significance is much more complex.

Nowadays it appears that virtually all of the constituent oak species are to be found not only in the supra- but also in the meso- and indeed in the thermo-Mediterranean where they constitute specific vegetation groupings and series. This is particularly true for *Q. pubescens* in the French meso-Mediterranean (Loisel, 1976), *Q. canariensis* and *Quercus faginea* in the meso- and supra-Mediterranean in Spain and the Maghreb (Rivas-Martinez, 1974; Barbero *et al*., 1988a,b), *Quercus brachyphilla* under the same conditions in Crete (Barbero and Quézel, 1980) and *Quercus cerris* and *Quercus macrolepis* in Greece and southern Anatolia (Barbero and Quézel, 1976; Akman *et al.*, 1978). Nonetheless, these structures display precise ecological requisites, principally in edaphically; they colonise terrain with deep soils and they can occur in humid bioclimates, particularly in the Maghreb, or subhumid bioclimates. Such scrublands are generally not very developed and often went unnoticed on account of the intensive and widespread use made of them by humans from Neolithic times onwards. In Islamic countries, that is, those with a dense population, they disappeared, or rather failed to regenerate, except in the maraboutic areas. At present a sustained phase of abandonment has favoured their return, especially in the French Mediterranean region.

In the mountainous Mediterranean belt, broadleaved forests may be found, namely, various stands of beech (*Fagus sylvatica, F. orientalis*) or oak (*Quercus sessiflora sensu lato*), particularly in southern Italy including Sicily, Greece and southern Anatolia (Brullo, 1983; Akman *et al.*, 1979a,b), where the date of dissemination, undoubtedly around the end of the Atlantic, remains to be established in the absence of accurate data. In the Mediterranean region, various other broadleaved species are found, which are generally only associates of the predominant oak structures, and include the genera *Acer, Tilia, Fraxinus, Ulmus, Corylus*, and so on. In the eastern Mediterranean, only *Ostrya* and *Carpinus orientalis* tend to make up a genuine vegetation series according to ecological criteria, and their history is analogous to that of the broadleaved oak (Bottema and Van Zeist, 1981).

These observations show clearly that in the current climatic conditions broadleaved forests should not be excluded from the potential climaxes of the thermo- and meso-Mediterranean belts. Their sporadic occurrence or virtual absence in zones with annual rainfall in excess of 600 to 700 mm is in fact a direct consequence of their progressive elimination by human activity, rather than by climate changes, over more than six millennia in the western Mediterranean and over an even longer time span in the eastern Mediterranean. In reality, the cooling that occurred in the sub-Boreal, should actually have favoured their extension.

We can recall that, in general terms for the entire Mediterranean basin, historical documentation suggests that broadleaved forests took hold in a comprehensive way from the end of the pre-Boreal along the northern rim and in the near East (Reille *et al.*, 1980; Triat-Laval, 1982; Van Zeist and Bottema, 1982) before the sclerophyllous oak stands appeared in any significant numbers (cf. supra), except in Syria. Further south they persisted side by side in roughly equal numbers in the coastal zone of northern Africa (Ben Tiba and Reille, 1982), until after the Atlantic, when the sclerophyllous oaks became predominant.

Within this context, riparian and alluvial forests constitute exclusively broadleaved species (Quézel, 1995) and should be mentioned, although they often represent azonal type structures. They comprise the genera *Alnus, Populus, Fraxinus* and *Salix* in particular, and we can add *Platanus orientalis* to this for the eastern side of the basin, and also, very locally, *Liquidambar* and *Pterocarya*. Their distribution is recent and concerns areas most seriously affected by human activity.

1.2.3.3 Mountainous forests

Currently, the mountainous Mediterranean forests are essentially dominated by coniferous species except on the northernmost fringes of the basin, particularly *P. nigra, Abies* spp., and *Cedrus* spp. Their ecological requisites and floristic structure are well known (Barbero *et al.*, 1981; Quézel and Barbero, 1985; Quézel et Médail 2003). Although various species, including *Abies cephalonica*, *Abies pinsapo*, *Abies maroccana* and in particular some forms of *P. nigra* have abundantly colonised the supra-Mediterranean belt, it is in the montane-Mediterranean, that is, above 1200 to 1600 m according to latitude, that they reach a well-developed state. The species that constitute these forests clearly belong to a typically Mediterranean composition formed before the glacial era, but unfortunately only very fragmentary data on their distribution history are available.

In southern France, Triat-Laval (1982) demonstrated that during the Boreal, low-level refuges of *Abies* and even *Fagus* existed, neither of which can be considered typically Mediterranean species. *P. nigra* subsp. *Salzmannii* is still found in Languedoc and Roussillon (Quézel and Barbero, 1988a,b), but must have disappeared recently in the Provence, since Vernet (1973) records it there at 10,000 BP in the charcoal from the cave of Fontbrégoua. In Corsica, Reille (1975, 1988) has shown that *P. nigra* subsp. *laricio* is present in the mountains, together with substantial scrublands from the end of the Würm and above all in the pre-Boreal (Reille *et al.*, 1997). In northern Africa, the most striking finding is that of Ben Tiba and Reille (1982) who confirmed the presence of *Abies* and *Cedrus* in the peatbogs around Aïn Draham in Tunisia. In Morocco, apart from the central and eastern High Atlas, *Cedrus* is present in dense forests from at least the Boreal onwards (Reille, 1976, 1977). Strangely, Lamb, Eicher and Switsur (1989) only recorded it from 4000 BP onwards in the mid-Atlas. In the eastern Mediterranean, the presence of *Cedrus, Abies* and *Pinus* (probably *P* *nigra*) pollen has been confirmed in southern Turkey on the Taurus (Van Zeist *et al*., 1975; Van Zeist and Bottema, 1982), and also on the Syrian coast, certainly after the end of the Würm in the pre-steppe-forest stage, and thereafter in forests from 8000 BP onwards.

1.2.4 Matorrals

At present the term *matorral* (Quézel, 1981) embraces all the scrublands of prevalently evergreen chamephytes and nanophanerophytes, which play a fundamental role in today's Mediterranean landscapes and in the dynamics of the arborescent scrublands according to the overall scheme in Figure 1.3 (Braun-Blanquet, 1936; Barbero *et al*., 1988a,b). This scheme can be either progressive or regressive, but in current conditions anthropic influences make degradation by far the most common process. Matorrals cover more than half the Mediterranean region due to a variety of activities (Tomaselli, 1976; Le Houerou, 1981), including deliberate burning, grazing and voluntary destruction of forest land. Under these conditions, we may wonder about the role of these vegetation structures in the distribution of the Mediterranean landscapes.

The floristic richness of the matorrals, in particular in endemic species, leaves no doubt about their ancient origins. The historical documentation (Pons, 1981) regrettably affords only very piecemeal evidence. Nonetheless, as we have seen, a substantial number of genera associated with matorral landscapes exist in the Mediterranean basin from the Miocene or indeed from the end of the Eocene onwards. Such ancient origins, combined with the vicissitudes of the climate after the end of the Pliocene, undoubtedly explain the floristic richness of these matorrals, which went through the various phases of expansion in the post-glacial period and of territorial recuperation by the vegetation, or else were reduced or even eliminated altogether in the forestal phase. In this situation, they could only develop in marginal sites: rocky environments, shallow soils, particular substrata (ultrabasic or dolomitic rocks in particular), or else in the presence of constant natural disturbances.

High-level matorrals, which are essentially *thermic-based*, and in particular spiny xerophyte scrublands in high mountains (Emberger, 1939; Quézel, 1952, 1973), constitute landscapes that are undoubtedly mere souvenirs of the scrublands that developed extensively during the cold phases of the Quaternary, such as those that now predominate on the Irano-Turanian mountains (Klein, 1994). As this study shows, the extension of matorral species has come in line, in spite of the difficulties, with what a certain number of historical documents suggest (Beug, 1961, 1967; Triat, 1978; Reille, 1976, 1977; Ben Tiba and Reille, 1982); the first stages of forest recuperation in the Alleröd, subsequently in the pre-Boreal, and particularly as a result of human activity in the sub-Boreal, thereafter reaching a peak, for the same reasons, in modern times.

A striking case study is that of the Corse scrublands where Reille (1988) was able to follow *Erica arborea* from the end of the Boreal, when at a local level they constituted dense scrublands practically devoid of *Quercus* pollen, up to the end of the Atlantic, thus predating the rise of human activity on the island.

Nonetheless, practically everywhere throughout the Mediterranean the extension of the matorrals has been and still is directly influenced by forest fires. These would have been started by natural causes up until the Atlantic and started deliberately thereafter mostly by people on the move needing to extend both grazing and farmland. They progressively eliminated the tree scrublands (particularly pre-forests and sclerophyllous forests). Finally, we should point out that in regions of highest anthropic impact, human destruction of the matorrals follows deforestation. This

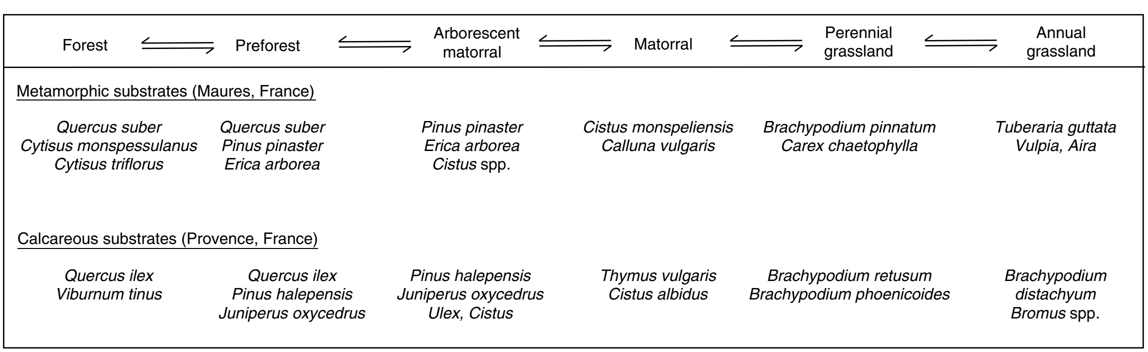

Figure 1.3 Schematic vegetation dynamics in Southern France

"dematorralisation" (Barbero and Quézel, 1995) is particularly evident in the semiarid Maghreb, where it leads to an extension of the herbaceous and annual scrublands, and even to a proliferation of toxic and thorny species immune to ruminants.

1.2.5 Steppes

Widespread in arid bioclimates, especially in the southern and eastern Mediterranean, steppes pose considerable problems from an interpretative point of view. At present they fall into two large groups with very different characteristics.

In the Maghreb and the Near East they constitute a transition zone in biogeographical and ecological terms between the Sahara and the Mediterranean region; their floristic composition is relatively poor and their vegetation shows little variation (Le Houerou, 1969, 1995), that is, steppes with *Artemisia*, *Stipa tenacissima*, *Salsolaceae*, steppes on chalky substrata and halophilous steppes. They spread over considerable areas, especially on the high plateaux, as a result of human activity, where they have progressively replaced the pre-steppe-forest structures described above. However, we do not yet have the precise historical data to determine what part human action played in primitive and secondary steppe landscapes.

The second group is floristically very rich and has a very varied vegetation (Akman *et al.*, 1984) such as in central Anatolia. We do not know much about their history but Bottema and Van Zeist, 1981 estimate that they remained in continuity with the Irano-Turanian steppes until about 4000 BP, which would explain their floristic richness. The Iberian steppes also fall into this group on account of their floristic variety and richness (Peinado-Lorca and Rivas-Martinez, 1987).

It would be most interesting to know if the steppes that are known today bear any analogy with those that developed virtually all through the Mediterranean at the time of the great glacial phases in the Quaternary. Palynologists are unanimous in recognising, for the last glaciation in particular, a relatively homogeneous floristic composition in this entire region, dominated by the pollens of *Artemisia, Ephedra, Helianthemum, Chenopodiaceae, Poaceae, Plantaginaceae, Apiaceae, Brassicaceae, Asteraceae*, and so on, although it is not currently possible to proceed to a more specific determination. It is clear that these genera or families are often predominant in the current steppes, but work still needs to be done at a general interpretative level on these pollen compositions, bearing in mind that dissemination caused by the wind over large distances always has to be considered for small-sized pollens in an asylvatic phase.

1.2.6 Grasslands

We have seen that there is very little historical documentation for matorrals and steppes, but it is practically non-existent for grasslands, which are, nonetheless, one of the most widespread vegetation structures in the Mediterranean basin at present. Plenty of pollen of *Poaceae* and various herbs appear in pollen spectra, but in this case it is practically impossible to identify the species or even genus for the *Poaceae*. Besides, these species play a significant role in the floristic composition of the steppes, matorrals and indeed in pre-steppe-forests of the Mediterranean basin. In such circumstances, it is more rational to set about their interpretation on the basis of current or sub-current phenomena.

There is no doubt that the Mediterranean grasslands constitute types of vegetation that have almost invariably been created and extended by the voluntary human action associated with herding. However, these structures can be integrated into the dynamic series mentioned above, and the abandonment of the sites *ipso facto* brings about regeneration by shrubs (steppe or matorral) in the dynamic series. This situation may either be due to a drop in, or indeed the disappearance of, the pressure of grazing herds, or to the abandonment of burning as a technique to renew grazing land (Joffre, 1982).

If such underusage continues, it will bring about the appearance of classic pre-forestal structures featuring *Juniperus, Pinus*, and so on. But excessive use (overgrazing, over a long period, and too frequent burning) leads to a negative dynamic and can transform classic grazing land with perennial species into annual grazing land that is much less productive and less significant from the economical viewpoint, and may in turn be destabilised by the invasion of toxic or unattractive and often thorny species. While the former process tends to be widespread in the northern Mediterranean, the latter represents the general rule more or less in the countries of the Maghreb and the Near East (Quézel and Barbero, 1988a,b). Such a scenario, which is now well known to researchers, has led to a destructuring of numerous arboreal scrublands in these regions that are destined to disappear rapidly, including oaks, pines, thuya (Benabid, 1976; Djebaili, 1990), cedars (Akman *et al.*, 1979; Quézel *et al.*, 1988), and argania (Peltier, 1982), where ground cover consists of a fairly dense carpet of annuals, in which *Stipa capensis* is often predominant (therophitisation *sensu* Barbero and Quézel, 1995).

1.3 CONCLUSIONS

We have seen that the vegetation structures and the most important landscapes in the Mediterranean basin are currently the result of both climatic changes that took place over some 12 millennia and modern local ecological factors. Among the latter, geomorphology, temperature and precipitation have played a fundamental role in the organisation of the large-scale arboreal groupings, as well as in the shrublands and herbaceous grasslands, which often are their derivatives. But the last phase of climatic improvement corresponded with the explosion of those civilisations, especially from its mid-point onwards, which profoundly upset the natural equilibrium that had been established.

The intensive increase in grazing and subsequently farming led to far-reaching changes, which had, as their most apparent consequence, a massive reduction of the forests, the cultivation of land and large-scale extension of grazing land. In the space of a few millennia, with the exception of some mountain zones that were partially spared, human action profoundly altered the ecological balance that had been achieved over 4 or 5 millennia, so that nowadays it is difficult, especially in low-lying belts and on deep soils, to form a precise idea about the original vegetation. The arboreal species, where they still exist, occupy only minimal areas compared to their potential initial cover.

The primary forests, which are by definition plurispecific, have generally become scarcely varied or indeed monospecific. Their opening up, followed by the spread of burning practices, has favoured the extension of chamephytes, and also of scrublands or of perennial grasslands, which, by excessive use and soil erosion, have transformed into annual grasslands. A precarious equilibrium has come into being, linked to a more or less controlled traditional land use, in different periods such as the Roman Empire, the Middle Ages, and the eighteenth and nineteenth centuries in particular (Godron, 1989). This may have created a certain impression of stability (Kunholtz-Lordat, 1938), but the radical economic and social transformations that have taken place since the end of the last century have upset this balance once again.

The northern countries that have been affected by industrial development and the marked abandonment of the land in zones of low productivity has favoured a biological recuperation featuring, above all, expansionist conifers such as *P. halepensis* and *P. sylvestris* in particular, which in spite of the spread of forest fires has led, for example, in Provence, to a doubling of the areas of natural population in less than a century (Barbero and Quézel, 1990), and the widespread renewal of the matorral through the reconstitution of the pre-forestal structures based above all on *Quercus coccifera* and the widespread closing of herbaceous scrublands. The human residential presence, locally important and very intense in coastal zones, is an additional cause of disturbance. This has led to a significant loss in biodiversity as a direct consequence, and it also leads to uniformity in the landscapes, which is not compatible with the generalised perception of the Mediterranean world.

On the other hand, the countries to the south and east of the basin have a sizeable population growth combined with a still predominantly precarious way of life, which has led to an exacerbation of the use of natural resources: illegal tree felling, forest clearance, intensive grazing and misuse of the matorrals and steppes has led to the rapid destruction of the biological heritage (cf. above). Currently, for example, more than half of the north African forests have been destroyed or at least have been profoundly altered in the space of only a few decades, and steppes and matorrals are being transformed into grasslands with annuals with a very low yield, progressively invaded by thorny or toxic species.

In each of these cases, and for the opposite reasons, the Mediterranean vegetation is currently undergoing drastic and rapid transformations, which are undoubtedly every bit as far-reaching as those that characterised the first half of the Holocene!

1.4 ACKNOWLEDGEMENTS

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2

Forest History in the Mediterranean Region

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2.1 INTRODUCTION

This book presents a review of the land-use changes of the vegetation and landscape in the Mediterranean basin in recent times. Studies of vegetation dynamics in Mediterranean countries, as driven by anthropogenic factors, are usually vegetation histories, with the complex interactions of man and vegetation rarely studied. In his work on the Mediterranean, Braudel (1988) analyses the history of the regions indicating their complexity and the resulting difficulty of explanation for these systems. Northern European authors (Thirgood, 1981; Rackham and Moody, 1996), have developed an approach that allows us to interpret the vegetation as a part of a "Cultural Landscape". This theoretical approach implies that the anthropic impact must be analysed alongside the vegetation (Berglund, 1991).

In the Mediterranean, the first "cultural landscapes" appear with the Neolithic societies, present more than 9000 years ago in the Middle East (Zohary and Hopf, 1994) when human societies began to manage their natural resources and began to cultivate species already used by the hunter-gatherer societies. The spread of the Neolithic civilisation transformed the landscape that was dominated by primary forests into a mosaic of areas with stands of trees and agriculture. The remaining woodlands were used as a source of fuel such as charcoal, for timber and wood for buildings and for weapons tools. This use of biomass is the most important factor in the relationship between man and forest in the Mediterranean over the last eight millennia, from the Neolithic Age until the first half of the twentieth century (Figure 2.1).

In this context, some natural vegetation has followed civilisation through time and space; besides the well-known history of cereals, vine and olive trees, an economic history of forest resources has helped to shape the landscape in the Mediterranean basin. In fact, the distribution of some species around the Mediterranean, such as the chestnut tree (*Castanea sativa*) and the Italian stone pine (*Pinus pinea*), represents a problem in traditional bio-geographical study because man has strongly influenced the distribution of these species in the last 8000 years (Quézel *et al.*, 1990). The current distribution of *Pinus halepensis*, *Cupressus sempervirens*, *Quercus coccifera*, *Ceratonia siliqua* and others species (Figure 2.2) are probably linked more to human management than to ecological factors. The great variety of traditional use of the forest described by Plinius in *De rerum Natuae* and in Columella's *De re Rustica* is only a part of the very diversified economy of the forest in the past. Moreover, not only trees but even shrubby species have been an important economic resource since the beginning of the twentieth century.

Processes often linked to anthropisation such as degradation, fire and grazing, are frequently used in a generic way as causes of degradation. In fact, little is

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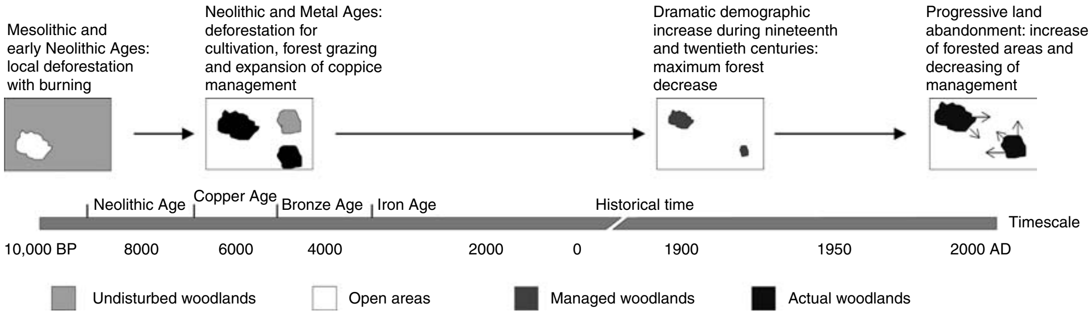

Figure 2.1 A generalised history of vegetation and landscape dynamics in the Mediterranean Basin

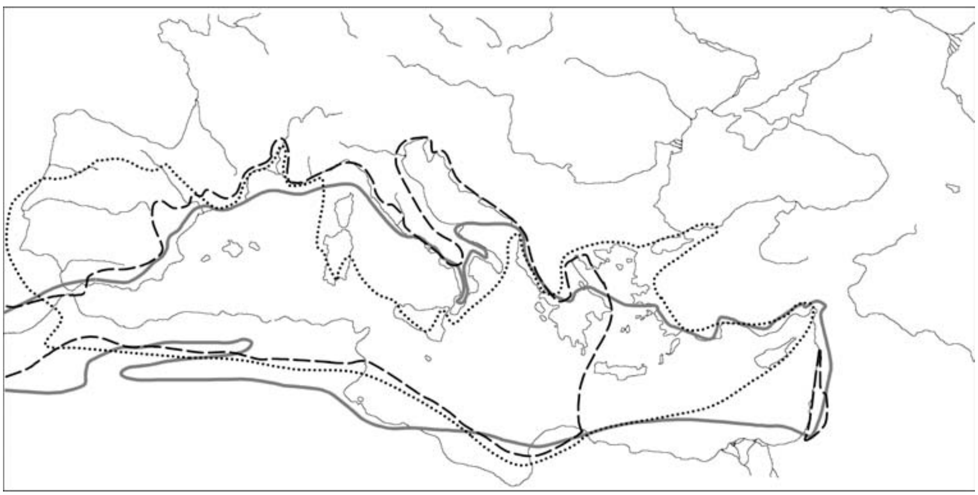

Figure 2.2 Current distribution of *C. siliqua* (——), *Q. coccifera* (· · · · ·) and *P. halepensis* (– – –)

known of the dynamic processes that have produced the current vegetation and landscape in the Mediterranean, but an important factor is likely to be the use, planned or otherwise, of the forest resource. We have little idea of the beginning, the duration, the intensity and the gaps in this use. The forest vegetation can be read as an element of the mosaic of cultural landscapes of various ages and therefore it can be studied like an archaeological feature (Rackham, 1992); but it is curious that this approach, based on different and rich materials (biological, archaeological and historical), is rarely taken up by ecologists and environmental experts.

One may extend this study to the notion that if Mediterranean landscapes are the result of man-induced changes, it is to be expected that the abandonment and the cessation of human practices, as is obvious in recent years, should lead to the progressive loss of the system as we know it.

2.2 CUTTING

The relationship between trees and human activities is very complex (Rackham, 1992) and it depends on the species' reaction to being cut. Some species just die whereas others sprout from the cut surface (as in coppicing) or produce root suckers. The study of these regeneration processes has led to the development of specific silvicultural techniques and some of these, such as the coppicing and the suckering practices, have been used to model the greater part of the forest and woodlands in the Mediterranean area (Figure 2.3). The coppicing practices of the past have shaped forests composed of deciduous and/or evergreen broadleaved species. The structures of these forests with small stem diameters and short tree heights can be attributed to the coppicing practices. Rackham, 1992 reports that until 1950 man has used almost all the herbaceous and arboreal species in Crete, and also that the greater part of the trees still present that are