Mediterranean Island Landscapes

Natural and Cultural Approaches

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I.N. Vogiatzakis • G. Pungetti • A.M. Mannion
Editors

Mediterranean Island Landscapes

Natural and Cultural Approaches

Springer

I.N. Vogiatzakis
Centre for Agri-Environmental Research
School of Agriculture Policy and Development
University of Reading
Earley Gate RG6 6AR
Reading Berks
UK

G. Pungetti
CCLP & University of Cambridge
UK

A.M. Mannion
University of Reading
UK

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Editors' Profiles

Dr Ioannis Vogiatzakis is a Research Fellow at the Centre for Agri-Environmental Research (CAER) at the University of Reading and a visiting Lecturer at the Department of Environmental and Natural Resources Management, University of Ioannina. With a PhD on the vegetation of Crete, he is an expert on Mediterranean ecology and has specific research and teaching interests in nature conservation of Mediterranean island ecosystems. He is a Fellow of the Royal Geographic Society and a member of the International Association of Landscape Ecology, the BES and IAVS. He has been consultant to UNEP PAP/RAC on Mediterranean Landscape Assessment.

Dr Gloria Pungetti is Scholar in Landscape at the University of Cambridge, member of Darwin College and Director of the Cambridge Centre for Landscape and People. With a Cantab PhD on holistic landscape research, she has advanced landscape studies linking culture with nature and theory with practice in Europe and the Mediterranean. She has international experience in landscape and nature conservation research for governmental bodies and NGOs, and in coordinating interdisciplinary projects focussing on cultural landscape and holistic landscape ecology, planning and policy. She is member of IALE, WWF, UN and IUCN working groups and of IUCN-CSVPA Task Force Board on cultural and spiritual values of nature, where she had the opportunity to collaborate with most of the authors of the book. She has published papers in scientific journals, chapters in books, reports and 6 books in several languages among which are:

Pungetti, G. (1996) Landscape in Sardinia: History Features Policies. CUEC, Cagliari. pp.158 (in English and Italian)
Makhzoumi, J. and Pungetti, G. (1999) Ecological Landscape Design and Planning: The Mediterranean context. Spon-Routledge, London, pp.330 (in English and Chinese)
Jongman, R.H.G. and Pungetti, G. (eds) (2004) Ecological Networks and Greenways: Concept, design, implementation. Cambridge University Press, pp.325 (in English, Chinese and Korean).

Dr Antoinette M. Mannion, formerly Senior Lecturer, is an Honorary Fellow in the Department of Geography, the University of Reading. Her interests are in physical geography, environmental change, environmental history, people-environment relationships, biogeography, ecology, agriculture-environment interactions including biotechnology, environmental issues. Dr Mannion has written/edited eight books and numerous papers as well as contributing to more than twenty edited books and encyclopaedias. Recent books include:

Mannion, A.M. (1997) Global Environmental Change (2nd ed), Longman.
Mannion, A.M. (1999) Natural Environmental Change, Routledge.
Mannion, A.M. (2002) Dynamic World: Land-cover and Land-use Change, Arnold.
Mannion, A.M. (2006) Carbon and its Domestication, Springer.

Foreword by the Series Editors

With the Springer Landscape Series we want to provide a much-needed forum for dealing with the complexity of landscape types that occur, and are studied, globally. It is crucial that the series highlights the richness of global landscape diversity – both in the landscapes themselves and in the approaches used in their study. Moreover, while the multiplicity of relevant academic disciplines and approaches is characteristic of landscape research, we also aim to provide a place where the synthesis and integration of different knowledge cultures is common practice.

Mediterranean Island Landscapes is the ninth volume of the series. The volume presents a comprehensive overview on history, developments and characteristics of Mediterranean Island landscapes. The volume editors, Ioannis N. Vogiatzakis, Gloria Pungetti and Antoinette M. Mannion provide an excellent introduction to the unique landscapes of Mediterranean Islands. To many people these islands are well known and are appreciated destinations for leisure and vacations. This book sheds an interesting light on Mediterranean Island landscapes by presenting natural and cultural developments of the region and their main islands. The book' gives evidence of a truly landscape-oriented approach in studying the Mediterranean Islands: The first part covers palaeoenvironmental history and biogeographical details as well as cultural and political particularities of the Mediterranean Islands. The second part provides a unique account of the landscapes characteristics of seven different islands/groups of islands. The third part discusses future strategies for landscape development. The volume editors have assembled a coherent and well-grounded collection of the latest research on Mediterranean Island landscapes, written by a selected group of well-informed researchers. The volume covers a subject that clearly deserves more attention. We recommend the book for all landscape researchers working on the various aspects of the Mediterranean Island landscapes whether covering natural or cultural approaches and particularly recommend the book to those readers who are interested in bridging natural and cultural approaches for the benefit of greater understanding the special character of the Mediterranean region.

Toulouse and Aberdeen
May 2007

Henri Décamps
Bärbel Tress
Gunther Tress

Foreword

by Zev Naveh

The renowned physicist and science philosopher David Bohm lucidly analyzed the deeply ingrained tendency to fragmentize and take apart what is in reality whole and one. This is true also for the prevailing views of human–nature relations and the resulting unfortunate rift between exclusively biocentric and anthropocentric approaches to Mediterranean landscapes in most studies. As the first comprehensive study of the Mediterranean Islands Landscapes (MIL), synthesizing in a holistic way the fragmentized information available, this anthology is very welcome. Some of the most knowledgeable Mediterranean experts in all relevant fields of natural, social and human sciences have joined forces, presenting a holistic and even a transdisciplinary view of natural, semi-natural and cultural landscapes, their history, present features and threats, and their needs to ensure their sustainable future.

The first section presents a general overview MIL, their geological Tertiary, Quarterly, and cultural Holocene history, their comparative biogeography and cultural and political landscapes, providing the background for the second section of a detailed consideration of the seven largest islands, chosen out of c.5,000. In the third section landscape strategies are discussed and the main conclusions are drawn.

This wealth of well-edited information enriches our knowledge by learning from the past, comprehending the present and what seems for me the most important issue, envisaging the future of the MIL. It will be of great general interest, but of special benefit for all those directly involved in their fate, namely the scientists, professionals and political decision-makers and above all the inhabitants who have the greatest stake in this.

Most of these islands can serve as unparalleled examples for the long-lasting and far-reaching impacts of the turbulent geophysical, climatic, biotic and anthropogenic changes these landscapes have undergone from their geological past until the present. We have sufficient archeological evidence from Mediterranean mainland landscapes to assume that human-induced ‘cultural’ changes have modified the pristine, natural landscapes in a coevolutionary process between the Pleistocene food collectors-hunters and their fire-swept landscapes into semi-natural landscapes. For the Mediterranean Islands we have only evidence that from the Early Holocene onwards, their natural landscapes were converted into human – dominated agro-silvo-pastoral landscapes, and most recently also into 'political' landscapes, reflecting cultural, ecological and economic factors in the political agenda.

Through this close interaction between natural and cultural landscape patterns and processes, these 'cultural biosphere landscapes' are the tangible meeting points and bridges between nature and mind and the biosphere and noosphere components of our Total Human Ecosystem. In the MIL, their biodiversity and smaller-scale ecological heterogeneity has been enriched by higher degrees of endemism. Coupled with their rich natural and cultural history, it resulted in their striking floristic, faunistic and cultural diversity and scenic attractiveness – or 'Total Landscape Ecodiversity'.

This can explain why, in spite of their common insularity, there is so much diversification in ecological and cultural features and in their social, economic and political – administrative fabric. However, it should be realized that the conservation of this remarkable ecodiversity and their assets can only be maintained by the continuation of all vital natural and cultural defoliation pressures, including controlled grazing, cutting, coppicing, burning, as well cultivation, together with the conservation and active restoration of all cultural assets, such as ancient terraces and historical buildings. Such dynamic conservation management of insular ecodiversity should become therefore also one of the major transdisciplinary challenges for their sustainable development. At the same time, MIL with their much shorter coast lines, are even more exposed than their much larger mainland land counterparts to the devastating effects of exponentially growing mass tourism and to the catastrophic repercussions of the rapidly increasing global climatic warming, causing – among others – heavy floods and water deficiency. Therefore efficient and well coordinated actions for the prevention of these dangers to nature and human life, their threats to ecodiversity, and stability are urgently needed in holistic Master Plan Strategies for MIL as advocated in this book.

However, these landscapes are presently considered 'the strategically fringes of continental Europe' and could be further neglected politically and financially as attention is turned to the new continental member countries. The EU Common Agricultural Policy (CAP) failed to recognize the special ecological and socio-economic conditions of these islands and their fragile mountainous landscapes on which only terraced slopes should be cultivated. Great sums of EU subsidies have promoted the 'bulldozerising' of the protective maquis vegetation to make room for large-scale intensively cultivated and irrigated olive plantations, causing erosion and destruction of these multifunctional landscapes and their 'hard' and 'soft' landscape values.

Already in 1992 we initiated an EU-sponsored study on 'Red Books of Threatened Landscapes' in Western Crete to gain greater public environmental conservation awareness and apprehension, to change the attitudes of decision-makers, and to provide practical guidance. Some of its results have been included also in this book. Fortunately, in recent years encouraging initiatives and projects recognize the need for integrated landscape protection, conservation, and restoration. The book concludes by summarizing the major issues and contributing additional important considerations and methods to these goals.

Let us hope that all these activities will have a real impact on future more sustainable land use and development in these islands. I am confident that this book will fulfill an important message for the recognition of the unique multifunctional, and transdisciplinary character of their landscapes, offering the most suitable ways to conserve their integrity, productivity and beauty for this and future generations.

Zev Naveh
Technion, Israel Institute of Technology,
Haifa, Israel

Preface

Worldwide, Mediterranean ecosystems rival tropical ecosystems in terms of biodiversity richness and are the most biodiverse ecosystems in Europe. As a result over the last 40 years there have been many books published on the five Mediterranean Type Climate regions of the world (Mediterranean Basin, Chile, California, South Africa, South-west Australia) and on the Mediterranean Basin in specific. The Mediterranean Islands have provided in the past refuge to plant and animal species and nowadays havens for people to escape. However, and despite their role as biological and cultural sanctuaries, in most scientific literature so far islands have been a part of the scene but, with few exceptions, rarely the protagonist. Moreover, there have been no attempts to approach the subject in a holistic manner incorporating culture and nature.

The vast number of islands in the Mediterranean region, c.5,000, makes the writing of a book on the Mediterranean Islands a life's task. Therefore it was evident from the outset that there should be some form of selection for reasons related to resources and the length of the book itself. Thus the editors decided to focus on the largest islands in the Mediterranean. The selection was thus confined to Sicily, Sardinia, Cyprus, Corsica, Crete, the Balearics and Malta. The latter although not a big island is a special case since it is an island state (includes archipelago). Moreover, and despite the importance of the seascape as a resource, and for transport purposes, the effects and environment of seascape were beyond the scope of this book. Therefore the emphasis has been on the terrestrial environment using landscape as the spatial framework to investigate the ecological but also cultural effects of insularity.

Any colleague who has worked in the Mediterranean Basin has come across the problems of research dissemination on Mediterranean Ecosystems. The plethora of working languages means that important work on the topic has not been published in international journals but in national or sometimes own institute's departmental (geographical) series. As a result a wider dissemination of a large part of information on the Mediterranean area is actually impeded.

Being a multilingual editing panel with multilingual contributors we have attempted to encompass literature resources on the topic from the majority of the official Mediterranean languages. As a synthesis of island information, this book is unique. It opens with chapters on the background to island landscapes: geology, biogeography, culture and politics. Then specific islands are examined in depth, each with a special topic to highlight a particularity. Finally, strategies for action are examined, formulated on the basis of a workshop held with the majority of the contributors at the University of Reading in May 2005.

Born in, having worked in, and fascinated by islands are the common ties that brought the editors and the authors together in this book in order to contribute to the topic of islands, their culture and their landscapes. One of the most prominent authorities in the Mediterranean flora Werner Greuter has recently written for the Mediterranean Islands: *Let us hope that we can hand down unspoilt, to the generations to come, that incredibly rich and valuable natural patrimony: the biota of the islands in the Mediterranean Sea* to that we feel the need to add *and the cultural heritage of these islands*.

A detailed account on the Mediterranean Islands is yet to be written.

I.N. Vogiatzakis
G. Pungetti
A.M. Mannion

Note: Given the different ways that various disciplines report dates, standardisation throughout the book was impossible. Therefore dates were left in their original published format. Prehistoric dates in Chapters 3 and 11 are presented as calibrated radiocarbon dates, that is the best known estimate of actual calendar years BC. Where necessary, dates as published in the original sources are adjusted to conform.

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Acknowledgements

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Contributors

Marie-Cécile Andrei-Ruiz
Office de l'Environnement de la Corse, Av. Jean Nicoli, 20250 Corte, France

Gaetano Benedetto
Ministry of Environment, Via Cristoforo Colombo 44, 147 Rome, Italy

Louis Cassar
International Environment Institute, Foundation for International Studies,
Old University Building, St. Paul Street, Valletta VLT 07, Malta.

Elisabeth Conrad
International Environment Institute, Foundation for International Studies,
Old University Building, St. Paul Street, Valletta VLT 07, Malta.

Penelope Delipetrou
Department of Botany, Faculty of Biology, University of Athens,
Panepistimiopolis, Athens, GR-15784, Greece

Panayiotis Dimopoulos
Department of Environmental and Natural Resources Management, University of Ioannina, Seferi 2, GR-30100, Agrinio, Greece

Kyriakos Georghiou
Department of Botany, Faculty of Biology, University of Athens,
Panepistimiopolis, Athens, Greece

Anna Giordano
WWF Italy, Via Po 25/c, 00198 Rome, Italy

Geoffrey Griffiths
Department of Geography, School of Human and Environmental Sciences,
The University of Reading, Whiteknights RG6 6AB, Reading, UK

Jala Makhzoumi
Landscape Design and Eco-Management, Faculty of Agricultural and Food Sciences, The American University of Beirut, P.O. Box 11-0236, Beirut, Lebanon

A.M Mannion
Department of Geography, School of Human and Environmental Sciences, The University of Reading, Whiteknights RG6 6AB Reading, UK

Alberto Marini
Department of Earth Sciences, University of Cagliari, Via Trentino 51 09100 Cagliari, Italy

Miguel Morey
Department of Biology, Universitat de les Illes Balears, Carretera Valldemossa, km 7.5, C.P. 07122 - Palma de Mallorca, Balearics, Spain

Florent Mouillot
IRD UR060, CEFE/CNRS (DREAM), 1919 Route de Mende, 34293 Montpellier Cedex 5, France

Thymio Papayannis
Mediterranean Institute for Nature and Anthropos (Med-INA), 23 Voucourestiou Street, 10671 Athens, Greece

Guilhan Paradis
Association Scientifique de Travaux, Études et Recherches sur l'Environnement (ASTERE), B.P. 846 – 20192, Ajaccio Cedex 4, France

Gloria Pungetti
Cambridge Centre for Landscape and People and University of Cambridge, UK

Angélique Quilichini
Laboratoire Evolution et Diversité Biologique, Université Paul Sabatier, Bâtiment IVR3 pièce 209, 118 route de Narbonne, 31 062 Toulouse Cedex 4, France

Oliver Rackham
Corpus Christi College, Trumpington St, Cambridge CB2 1RH, UK

Maurici Ruiz Perez
Instituto Mediterráneo de Estudios Avanzados (IMEDEA) C) Miquel Marqués 21, 07190 Esporles, Mallorca, Balearics, Spain

Patrick Schembri
Department of Biology, University of Malta, Msida Malta

Aphrodite Sorotou
Mediterranean Institute for Nature and Anthropos (Med-INA), 23 Voucourestiou Street, 10671 Athens, Greece

Ioannis Vogiatzakis
Centre for Agri-Environmental Research, School of Agriculture Policy and Development, The University of Reading, Earley Gate, RG6 6AR, Reading, UK

Part I
Nature and Culture in Mediterranean Islands

Chapter 1
Introduction to the Mediterranean Island Landscapes

I.N. Vogiatzakis[1], A.M. Mannion[2], and G. Pungetti[3]

The west Mediterranean Islands as seen from MODIS Terra satellite

1.1 Introduction

All Mediterranean Islands resemble each other; each island is different in its own way. Apart from their distinctive differences Mediterranean Islands share many characteristics with islands in general. Places of romance, excitement and adventure or just

[1] Centre for Agri-Environmental Research, University of Reading, UK

[2] Department of Geography, University of Reading, UK

[3] Cambridge Centre for Landscape and People and University of Cambridge, UK

I.N. Vogiatzakis et al. (eds.), *Mediterranean Island Landscapes.*

Table 1.1 Island political definitions (From EURISLES 2002; MEA 2005)

Source	Definition
UN Convention on the law of the seas Part VIII Article 121	An island is a naturally formed area of land, surrounded by water, which is above water at high tide
UNESCO Man and the Biosphere	Small islands are 10,000 km^2 or less in surface area with 500,000 or fewer residents
European Union	An 'island region' is a segment of a Member State which is entirely surrounded by sea, has no physical links to the mainland and is not the seat of the capital city of any European Union country
Council Regulation (EC) No. 2019/93	A smaller island is an island the permanent population of which does not exceed 100,000 inhabitants

escape from the pressures of busy lifestyles, islands worldwide have always held a particular fascination for people. Those of the Mediterranean Basin have a special place in human and environmental history. Due to their position, Mediterranean Islands are among the most visited, studied and exploited. They also feature prominently in subjects such as mythology, literature, radio, television and travelling material.

Although there are many definitions of what constitutes an island (Table 1.1), the *Oxford English Dictionary* definition is 'a piece of land surrounded by water'. This definition sets the scene for the notion of insularity which defines many of the characteristics and processes discussed in this book. The idea of the island laboratory initiated by the works of Charles Darwin (1859) on species and ecosystems was followed by Evans (1977) for humans and early societies. Islands are thus judged as natural laboratories and provide a foundation for the study of natural and cultural processes (MacArthur and Wilson 1967; Whittaker 1998; Patton 1996). Insularity is truly a limiting factor to resources, allowing hence scientists to study the ways in which biological or human communities have adapted to their environment. This limiting factor generates a self-contained microcosm, almost a closed system, with defined boundaries. This sets islands apart from the contiguity of the continents and thus defines a laboratory of manageable and quantifiable proportions.

Unlike isolated oceanic islands Mediterranean Islands are located adjacent to the mainland of three different continents (Fig. 1.1) with which they exhibit many similarities in biota and physical environments. In the past some of the largest islands hosted remarkable ancient civilizations; there are many similarities and many differences in the patterns and timing of human colonization just as there are differences in current anthropogenic activities. Ecologically the islands are individually unique and all are considered to be hotspots of biodiversity at a global scale (Médail and Quézel 1997; Davis et al. 1994).

The book addresses these issues and the major environmental changes that the islands experienced during the Quaternary. In particular it focuses on the changes

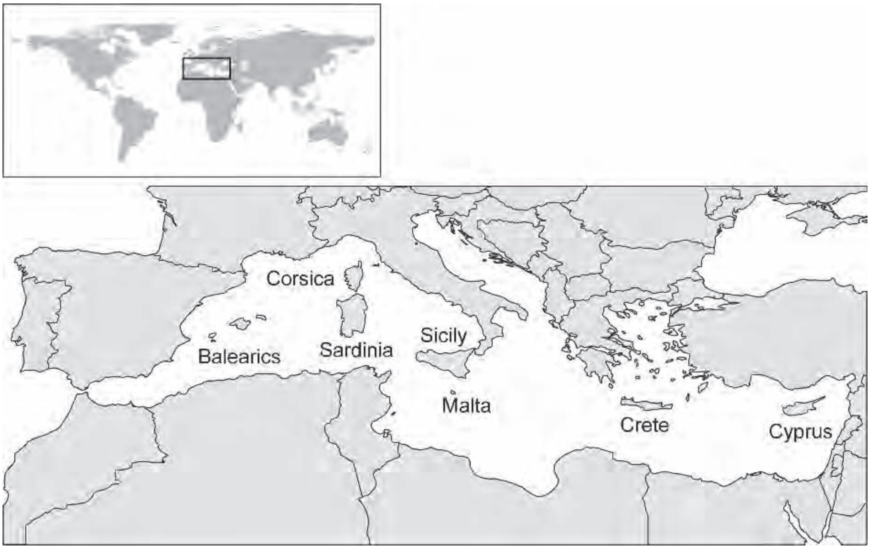


Fig. 1.1 The Mediterranean region and the major islands (Adapted from GLOBAL GIS © 2001 American Geological Institute. With permission)

during the Holocene, approximately the last 10,000 years, and their effects on biota, and on the current human pressures that are now threats to the sustainability of the island communities. The general aim of this book is to review the existing qualitative and quantitative information, which is currently fragmented, on the Mediterranean Islands' physical and cultural environments. The specific objectives of the book are to:

- Synthesize the fragmented information available on the islands' landscapes, by providing an overview of the landscape/environmental and ecological changes during the last 10,000 years, and comparing these changes between the different islands
- Enhance the understanding of the past and present in order to provide insights for the future
- Suggest sustainable land-use practices and new tools for conserving Mediterranean Island environments
- Explore a common strategy for sustainable development of the landscape and biota of Mediterranean Islands
- Fill a niche that is not serviced at present by current research

Overall there are c.5,000 Mediterranean Islands. However, it is the largest islands that dominate the Mediterranean scene (Table 1.2). They host indeed large numbers of biota, and are characterized by exceptional cultural elements while at the same time are subjected to the most intense environmental and socio-economic pressures. This is the reason why this book focuses on them.

Insularity is perceived and experienced differently by visitors and inhabitants. The latter consider that insularity is a disadvantage, especially in comparison with mainland regions. There are disadvantages directly related to the physical environment,

Table 1.2 Characteristics of the major Mediterranean Islands (After Hopkins 2002)

Island	Country	Size (km^2)	Population (1,000)	Density (inhab/km^2)
Sicily	Italy	25,708	5,097	198
Sardinia	Italy	24,090	1,661	69
Cyprus	Cyprus	9,241	784	85
Corsica	France	8,681	272*	29
Crete	Greece	8,261	559	68
Balearics	Spain	5,014	768	153
Maltese Archipelago	Malta	316	400	1,266

* See Chapter 10.

e.g. restricted resources including land, water, energy, coastal erosion, marine and coastal pollution, whereas others are a consequence of isolation from the mainland, e.g. difficult access to education and health services, absence of favourable conditions for many types of businesses, higher cost of living due to the need for imports, population decrease (Table 1.3). Visitors conversely, consider the coastline to be an asset and relative isolation a benefit in comparison with the hurly burly of urbanized continental areas. However, visitors spend relatively little time on their holiday destinations and so do not experience the long-term disadvantages.

Over the past few decades, changes in agricultural practices, especially the increase in animal husbandry, have resulted in biodiversity loss. Moreover, tourism has led to migration from rural to urban areas and to increased pressure on coastal ecosystems (Scapini 2002). Although these issues are common throughout the Mediterranean Basin, they are amplified in the islands due to insularity and specific constraints. Socio-economic problems, for example, are often compounded by the fragility and vulnerability of the islands. Consequently Mediterranean Islands experience greater difficulty in achieving a comparable level of development and standard of living when compared with the European mainland (EESC 2003).

Special reference must be made to tourism because it has been one of the most important factors in the Mediterranean Basin's socio-economic development in the last 50 years. The arrival of tourism in the islands has led to broader socio-economic and cultural changes and several unwelcome economic, environmental and sociocultural impacts which currently threaten the islands' sustainability (Briassoulis 2003). Tourism has been adopted universally in islands as a tool for development (Ioannides et al. 2001; Conlin and Baum 1995). In the case of the Mediterranean Islands, tourism is viewed as the only activity capable of reviving local economies (Kousis 2001). Even where cultural impacts are very strong, the economic benefits associated with tourism make it irresistible to local communities (Williams 1997). Examples of socio-economic and cultural problems include a degree of homogenization as food and recreation preferences from tourist homelands are adopted and which sometimes displace local traditions. Truly, the aspirations of many islanders tend to view tourism as a means of rapid wealth generator resulting in avoidance of other essential employment. The seasonality

Table 1.3 Permanent disadvantages of island regions (After EESC 2003)

Disadvantage	Nature
Isolation from the mainland	Physical
Higher cost of sea and air transport, communications and infrastructure on account of natural and climate-related obstacles	Economic
Restricted usable land area	Physical
Limited fishery resources	Physical
Restricted water supplies	Physical
Restricted sources of energy	Physical
Marine and coastal pollution	Physical
Special difficulties in waste management	Physical
Falling population, particularly of young people	Social
Coastal erosion	Physical
The shortage of qualified workforce	Social
The absence of favourable economic climate for businesses	Economic
Difficult access to education and health services	Social
Small scale and seasonal nature of local markets	Economic

of tourism as intensive work for just two thirds of the year is often considered preferable to all-year-round employment. Tourism also encourages a shift in population from rural to urban environments, and traditional jobs such as those linked with agriculture are hence eschewed.

The impacts of tourism on landscape degradation, with excessive demands on water supplies and problems of waste management are common issues throughout the coastal areas of the Mediterranean Basin, but in islands they are amplified. Another severe but unquantifiable problem is that of the invasion of alien plants and animals. Many of these problems will be compounded by global climate change and may, in turn, affect socio-economic activities including tourism.

Increasingly, however, the sand-sea complex is insufficient since the sophistication of tourists' demands grows. This can contribute to improved preservation of environmental quality because access is required to 'Nature', archaeology, good water quality and aesthetic environments. Therefore nature and/or cultural conservation is no longer necessarily an impediment to tourism development but a means for making the islands more attractive to visitors. It does, however, require good planning and active management.

1.2 Nature and Culture in the Mediterranean Islands

In this introductory chapter, the various subjects illustrated in this book and the organization of its content are explained. Part I comprises background chapters defining the major geological, environmental, cultural and socio-economic factors which have influenced Mediterranean Island landscapes in time and space. In Chapter 2 there is emphasis on Quaternary environmental changes. The separation of the African and European plates around 150 million years ago resulted in the formation of the Mediterranean Basin. Throughout the last part of the last ice age c.20,000 years ago the climate of the area was significantly drier and cooler than it is today. Faunal evidence shows the presence of horse, reindeer, mammoth and marmot, while palynological evidence suggests a predominance of grassland, with small areas of pine and deciduous woodland (Patton 1998). The coastlines of the Mediterranean have changed significantly since the end of the last ice age c.12,000 years ago due to sea level rise. Thus the biogeographic characteristics of islands today (i.e. size and distance from mainland) have been altered. At the time of the last glacial maximum (i.e. 18,000 years ago) Sardinia was joined to Corsica, Minorca to Mallorca, the Maltese and Egadi groups to Sicily. In the Aegean Sea most of the Cycladic islands were joined together while the islands in the north and east were part of the mainland (Patton 1996).

When humans first appeared in the Mediterranean Islands and when the islands were settled on a permanent basis are controversial issues. Table 1.4 gives a synopsis of generally accepted dates for the earliest establishment of a significant settlement on the islands discussed in this book. This table is indicative but not definitive, and caution is urged regarding its interpretation on several grounds. First, the falls and rises of sea levels as Quaternary ice advances waxed and waned have joined and severed the connections between most of these islands and the mainland and between islands too. Second, the evidence for human presence and related age estimations is patchy and sometimes controversial. Third, absence of evidence does not necessarily mean absence of humans, and presence of evidence does not necessarily mean the existence of a viable population with a permanent island home because it is highly likely that visits by mainland people occurred before and after permanent settlement.

A survey of island colonization including work up to 1989 by Cherry (1990) and a discussion of later prehistoric developments in Blake and Knapp (2005) provide additional information. Further insights into early human colonization of at least some of the islands are possible from the analysis of the genetic characteristics of present-day populations. During the last cold stage in Europe, Sykes (2001) has identified seven likely refugia for humans: Mount Parnassus (Greece), southern Russia, southern France, northern Spain, north-east Italy, Central Italy and the Euphrates region of Syria. As warm conditions developed, populations expanded from these refugia to people Europe. Genetic characteristics from populations in Italy and Sicily indicate two expansions c.20,500 and 8,000 years ago from the Italian refugia into Italy and Sicily. These same populations did not, however, colonize Sardinia (Francalacci et al. 2003) where genetic characteristics indicate a wave of colonization from southern France, or the Iberian peninsula, c.9,000 years ago (Rootsi et al. 2004). Corsican populations reflect instead colonization from the northern Italy refugium. Crete was probably colonized from mainland Greece and, on the basis of geography, Malta would have been susceptible to invasion from Sicily and north Africa.

In terms of environmental impact in the Mediterranean Islands, however, the early Holocene appears to have been crucial as the transformation of wildscapes into landscapes began. Thereafter these landscapes became increasingly modified by human activity, as discussed in Chapter 3.

From the time of Darwin (1859) and Wallace (1892) to MacArthur and Wilson (1967), scientists have been fascinated by the evolutionary biology of island biota, particularly in relation to factors determining species diversity, adaptive radiation and evolutionary changes within populations (Grant 1998; Whittaker 1998). Most of the islands in the Mediterranean are biodiversity hot spots which have provided refuge for many plant species, including endemics, and contributed to evolutionary differentiation (Blondel and Aronson 1999; Snogerup 1985). The large Mediterranean Islands *shared* some common elements before the arrival of humans such as dwarf elephants and hippos (Blondel and Aronson 1999) but also had distinct differences. Mediterranean Islands possess floras of special interest. They all contain a high number of endemic species, some relictual, others more recent and a high proportion of plants of Mediterranean Islands is endemic to the Mediterranean Basin including several wild relatives of crops (Heywood 1995; Greuter 1995). Landscape fragmentation due to human activity has also occurred. These factors together with the effects of insularity on biota, their biogeographical affinities and peculiarities are discussed in Chapter 4.

Apart from being biodiversity refuges, Mediterranean Islands provided the stages of some of Europe's most impressive early civilizations. Mediterranean Island landscapes have indeed great symbolic value; historical monuments and mediaeval cities are preserved on most islands and bear witness to their culturally powerful past. Moreover, new archaeological findings are constantly being unearthed. The Taulas and Talaiots of the Balearics, the Nuraghi and Torri of Sardinia and Corsica, the Neolithic stone Temples of Malta and Gozo and the Minoan Palaces of Crete are evidence of Europe's historical fabric. They also reflect the islands' importance to ancient civilizations and the role of the sea in their maintenance as cultural foci (Pungetti 1996).

Commonly throughout the Mediterranean Basin, human identities and cultures in the islands are diverse both historically and currently (Proudfoot and Smith 1997). Evans (1977) argued that just as insularity has profound consequences for biota it had similarly profound impacts on culture. What are the cultural effects of insularity? Moreover, if island communities have particular cultural features, has this resulted in a particular/distinct cultural landscape? These questions are considered in Chapter 5.

Albert Camus wrote: 'Generally, I like all islands. There it is easier to rule.' Islands, particularly those of smaller size, are often powerless in political terms. Although in prehistory many of the islands were characterized by remarkable indigenous civilizations in recent times mainland powers have dominated over islands. As discussed in Chapter 6, all the islands examined in this book have historically been in a position of political subservience to an outside power. Due to their strategic position many islands endured repeat invasions and wars; they were also instruments for defence, trade and exploitation of natural resources. First came the Greeks, followed by the Phoenicians, Etruscans, Carthaginians and the Romans; later came the Sarrasins, Genoans, Venetians and the Turks to mention but a few of the conquerors. Today, all but two of these islands are components of a mainland state belonging to the European Union (EU). The island states of Cyprus and Malta gained their independence relatively recently from the British and in most recently were admitted as members of the European Union in 2004. Other islands like Sicily, Sardinia and Corsica, although part of a mainland state, have retained an autonomous status with regional governments in place and in control of legislation and administration. At the national level, some of the changes in the last 100 years have been related either to policies of negligence or more recently with the implementation of EU legislation to policies of attention, since most of the islands were incorporated under the Least Favoured Areas, Objective 1. This has given rise to the distinct political landscapes of the Mediterranean Islands.

1.3 Mediterranean Island Landscapes

Part II focuses on individual islands. Chapter 7 deals with Sicily the largest and highest island in the Mediterranean with a rich archaeological heritage. It is dominated by the presence of Mt. Etna, one of the most active volcanoes in the world. The volcano has created and destroyed landscapes in the past and has influenced the culture of the people who have lived in its shadow. The west of the island is characterized by extensive citrus orchards surrounded by stonewalls and hedges, i.e. a typical Mediterranean garden landscape. In the island's centre there are agro-silvo-pastoral landscape remnants of the old feudalist system. Sicily's quasi-island status marks it out as different from the other islands because its prehistory is linked with that of Italy; humans were present at least 35,000 years ago though additional evidence points to a significant spread of human occupation c.9,000 years ago (Table 1.4). Due to its proximity to the mainland its environmental, ecological, cultural and socio-economic characteristics are thus close to those of South Italy which itself contrasts with North Italy.

Geologically, as described in Chapter 8, Sardinia has many affinities with Corsica since they originated from the Corsico-Sardinian complex, a 'continental microplate' which parted from the European plate in the Oligocene-Miocene some 30 million years ago, but their landscapes differ in many respects. Sardinia is the second largest island in the Mediterranean with a great variety of geological formations, particular morphological features such as *giare* and *tacchi* and a mining heritage. Early dates from Sardinia, c.13,500 years ago, are disputed but could reflect a Palaeolithic presence; later dates c.9,200 years ago are from deposits associated with human remains and artefacts. The island has extensive traditional landscapes and abundant dune systems, as well as a rich archaeological heritage. Despite widespread eucalypt plantations, the island has generally retained its semi-natural vegetation. Although not as widespread as in other Mediterranean Islands, tourism is increasingly becoming the main source of income.

Chapter 9 examines the island of Cyprus which is dominated by two mountain ranges parallel to each other in an east–west direction and which are separated by a wide plain. The remarkable site of Akrotiri, not only contains evidence for early

Table 1.4 A tentative chronology for the human colonization of Mediterranean Islands

Island	Date (approx BP)	Site	Reference
Sicily	37,000–20,000	Stone tools on Catania Plain and Agrigento province	Leighton 1999
	17,000–10,000	Abundant evidence from coastal caves	
Sardinia	13,500	Corbeddu Cave*	Hofmeijer 1997
	9,100	Corbeddu Cave	Sondaar et al. 1986
Cyprus	10,600	Akrotiri Aetokremnos	Simmons 1999
Corsica	11,500–9,500	Various rock shelters	Costa et al. 2003
Crete	8,000	Knossos	Rackham and Moody 1996
Balearics (disputed)	5,000–4,000	Various, e.g. Cova des	Alcover 2004
	7,000–8,000	Moro, Mallorca	
Malta	7,500	Ghar Dalam Cave	Trump and Cilia 2002

* Dates for Sardinia are disputed, see Chapter 3.

Holocene settlement of Cyprus but also for the active hunting of pygmy hippopotami; indeed, these hunter-gatherers may have been responsible for the latter's extinction. Copper extraction in the past has caused destruction of natural habitats. The British administration (1878–1960) contributed to the increase of forest cover by introducing and enforcing strict legislation, but also through extensive plantations of introduced species. Since 1974 Cyprus has been a divided island as a result of an armed-political conflict which gave rise to two distinct parts: an urbanized south and a predominantly rural north. Tourism dominates island economics.

Corsica, the subject of Chapter 10, is the second highest island in the Mediterranean; has a predominantly mountainous terrain with a well-defined extensive plain on the east coast. Geologically it has the same tectonic history as the Alps. The research of Costa et al. (2003) indicates similarities between Sardinian finds and Corsican rock shelters and probably reflects colonization by Mesolithic hunter-gatherers. The island has extensive forests and traditional agroforestry systems. Agriculture is less intensive than in other Mediterranean Islands while the population is concentrated in many small villages mainly on the mountain zone. Since c.1980 Corsica has experienced a fourfold increase in the number of tourists (Kousis 2001). Today it is an island with autonomous status, and a unique designation of natural parks that covers 40% of its area.

Crete is recognized as a Global Centre of Plant Diversity by the IUCN (Davis et al. 1994) due to its high degree of endemism. As discussed in Chapter 11 there are three principal mountain massifs on the island with several peaks over 2,000 m and karstic features including gorges, dolines, caves and underground rivers. Terraces, enclosures and greenhouses are examples of old and recent features which make up an extensive agricultural landscape. The dominant activities are sheep rearing, olive and vine production. The widespread tourist development on the north coast has led to the destruction of dune systems.

The penultimate chapter in Part II, Chapter 12, is concerned with the Balearics, an archipelago of 151 islands and islets only four of which are inhabited at present. Their remarkable geomorphology and isolation have resulted in a unique biodiversity, with differences occurring between the east and west islands of the archipelago. The Balearics are as archaeologically distinct as they are biogeographically distinct because they have always been isolated. The history of human colonization is controversial (see Alcover 2004) and centres on either an early or late colonization based on age estimations of c.8,000 and c.4,000 years ago. Approximately 40% of the islands' territory is under some type of environmental protection. The islands are among the most popular tourist destination in the Mediterranean; tourism is an income generator which exerts enormous pressure on land use and biodiversity.

Neolithic cultures are in evidence on all the islands through their legacy of ceramic technology and megalithic construction. The case of Malta, however, in Chapter 13 intriguing insofar as it was (most probably) joined to Sicily at several times in the last 2 million years and thus could have received humans at any time on their excursions out of Africa. Yet the earliest dates for human colonization are c.7,400 years ago, by which time a sophisticated culture was established. Malta, an island state, has experienced an increased economic development in the last 30 years resulting increased pressures on the landscape. The island's high population density, moreover, along with intensive tourism has brought significant pressures on the overall balance between rural and urban areas and ecosystems. Urbanization, intensive agriculture and hunting have resulted in great habitat loss and the decimation of bird populations.

1.4 Future Perspectives

Part III of the book deals with future perspectives. Based on the chapters focused on the individual islands (Chapters 7–13), Chapter 14 presents the founding of a landscape strategy for Mediterranean Island landscape development with a focus on multifunctionality. This has been central in the past to sustainable resource management in traditional Mediterranean rural landscapes (Naveh 1998; Makhzoumi and Pungetti 1999). Embracing the many roles of landscape in socio-economic terms, and the need for sustainable management of the integral natural and human resources are critical to ensure a viable future. Therefore, the chapter advocates the use of a holistic approach based on landscape ecology principles in order to develop strategies for the Mediterranean Island landscapes. This transdisciplinary approach brings together in a unified framework the natural and cultural elements of the landscape and is inclusive of the views expressed by scientists and stakeholders alike. The concluding chapter (Chapter 15) is a comparative summary of the landscape character and changes in the Mediterranean Islands; it underlines their differences and similarities, and highlights the challenges and prospects they face in the ensuing decades.

References

Alcover, J.A. (2004) Disentangling the Balearic first settlement issues. ENDINS 26: 143–156.

Blake, E. and Knapp, B. (eds.) (2005) The Archaeology of Mediterranean Prehistory. Blackwell: Oxford.

Blondel, J. and Aronson, J. (1999) Biology and Wildlife of the Mediterranean Region. Oxford University Press: Oxford.

Briasoulis, H. (2003) Crete: endowed by nature, privileged by geography, threatened by tourism? Journal of Sustainable Tourism 11: 97–115.

Cherry, J.F. (1990) The first colonization of the Mediterranean Islands: a review of recent research. Journal of Mediterranean Archaeology 3/2: 145–221.

Conlin, M.V. and Baum, T. (eds.) (1995) Island Tourism: Management Principles and Practices. Wiley: Chichester, UK.

Costa, L., Vigne, J.-D., Bocheras, H., Desse-Berset, N., Heinz, C., de Lanfranchi, F., Magdaleine, J., Ruas, M.-P., Thiebault, S. and Tozzi, C. (2003) Early settlement on Tyrrhenian islands (8th millennium cal. BC); Mesolithic adaptation to local resources in Corsica and northern Sardinia. In L. Larson, H. Kindgren, K. Knutsson, D. Loeffler and A. Akerlund (eds.) Mesolithic on the Move. Oxbow Books: Oxford, pp. 3–10.

Darwin, C. (1859) On the Origin of Species By Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life. John Murray: London.

Davis, S.D., Heywood, V.H. and Hamilton, A.C. (eds.) (1994) Centres of Plant Diversity, Vol. 1. IUCN.

EESC (European Economic and Social Committee) (2003) Trans-European Networks and Islands. Office for Official Publications of the European Communities: Luxembourg, 87 pp.

EURISLES (2002) Off the coast of Europe: European construction and the problem of the islands. Report for the Islands Commission of the Conference of the Peripheral and Maritime Regions (CPMR), 150 pp.

Evans, J.D. (1977). Island archaeology in the Mediterranean: problems and opportunities. World Archaeology 9(1): 12–26.

Francalacci et al. (2003) Peopling of three Mediterranean Islands (Corsica, Sardinia, and Sicily) inferred by Y-chromosome biallelic variability. American Journal of Physical Anthropology 121: 270–279.

Grant, P. (ed.) (1998) Evolution on Islands. Oxford University Press: Oxford.

Greuter, W. (1995) Origin and peculiarities of Mediterranean Island floras. Ecologia Mediterranea 21: 1–10.

Heywood, V.H. (1995) The Mediterranean flora in the context of world biodiversity. Ecologia Mediterranea 21(1/2): 11–18.

Hofmeijer, G.K. (1997) Late Pleistocene Deer Fossils from Corbeddu Cave: Implications for Human Colonization of the Island of Sardinia. British Archaeology Reports: Oxford.

Hopkins, L. (2002) IUCN and Mediterranean Islands: Opportunities for Biodiversity Conservation and Sustainable Use. IUCN, p. 63.

Ioannides, D., Apostolopoulos, Y. and Sonmez, S. (eds.) (2001) Mediterranean Islands and Sustainable Tourism Development: Practices, Management, and Policies. Continuum Publishers: London.

Kousis, M. (2001) Tourism and the environment in Corsica, Sardinia, Sicily and Crete. In D. Ioannides, Y. Apostolopoulos and S. Sonmez (eds.). Mediterranean Islands and Sustainable Tourism Development: Practices, Management, and Policies. Continuum Publishers: London, pp. 214–233.

Leighton, R. (1999) Sicily Before History. Duckworth: London.

MacArthur, R.H. and Wilson, E.O. (1967) The theory of island biogeography. Princeton University Press: Princeton, NJ.

Makhzoumi, J. and Pungetti, G. (1999) Ecological Landscape Design and Planning: The Mediterranean Context. E & FN Spon: London.

MEA (Millennium Ecosystem Assessment) (2005) Ecosystems and human well-being: current state and trends. Millennium Ecosystem Assessment Series. Island Press.

Médail, F. and Quézel, P. (1997) Hot-spots analysis for conservation of plant biodiversity in the Mediterranean Basin. Annals of the Missouri Botanical Gardens 84: 112–127.

Naveh, Z. (1998) From biodiversity to ecodiversity: holistic conservation of the biological and cultural diversity of Mediterranean landscapes. In P. Ruindel, G. Montenegro and F. Jaksic (eds.) Landscape Disturbance and Biodiversity in Mediterranean-type Ecosystems. Springer: Berlin.

Patton, M. (1996) Islands in Time: Island Sociogeography and Mediterranean prehistory. Routledge: New York.

Proudfoot, L. and Smith, B. (eds.) (1997) The Mediterranean: Environment and Society. Arnold: London.

Pungetti, G. (1996) Landscape in Sardinia: History Feature Policies. CUEC: Cagliari.

Rackham, O. and Moody, J.A. (1996) The Making of the Cretan Landscape. Manchester University Press: Manchester, UK.

Rootsi, S. et al. (2004) Phylogeography of Y-chromosome haplogroup I reveals distinct domains of prehistoric gene flow in Europe. American Journal of Human Genetics 75: 128–137.

Scapini, F. (ed.) (2002) Baseline research for the integrated sustainable management of Mediterranean sensitive coastal ecosystems. A Manual for Coastal Managers, Scientists and All Those Stydying Coastal Processes and Management in the Mediterranean. IAO: Florence, 223 pp.

Simmons, A.H. (1999) Faunal Extinction in an Island Society: Pygmy Hypopotamus Hunters of Cyprus. Kluwer: Dordrecht.

Snogerup, S. (1985). The Mediterranean Islands. In C. Gomez-Campo (ed.) Plant Conservation in the Mediterranean Area. Dortrecht.

Sondaar, P.Y., Sanges, M., Kotsakis, T. and de Boer, P.L. (1986) The Pleistocene deer hunter of Sardinia. Geobios 19: 17–25.

Sykes, B. (2001) The Seven Daughters of Eve. Bantam Press: London.

Trump, D.H. and Cilia, D. (2002) Malta: Prehistory and Temples. Midsea Books: Malta, 320 pp.

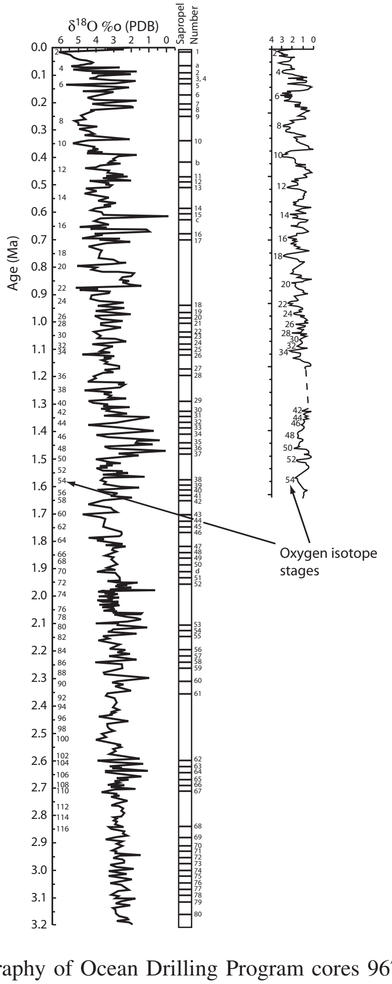
Wallace, A.R. (1892) Island Life: Or the Phenomena and Causes of Insular Faunas and Floras Including a Revision and Attempted Solution of the Problem of Geological Climates. Macmillan: London.

Whittaker, R.J. (1998) Island Biogeography. Oxford University Press: Oxford.

Williams, A. (1997) Tourism and uneven development in the Mediterranean. In R. King, L. Proudfoot and B. Smith (eds.) The Mediterranean: Environment and Society. Arnold, pp. 208–226.

Chapter 2
The Tertiary–Quaternary Environmental History of the Mediterranean Basin: The Background to Mediterranean Island Environments

A.M. Mannion



The oxygen-isotope stratigraphy of Ocean Drilling Program cores 967 (Eastern Mediterranean) and 976 (Western Mediterranean) based on Kroon et al. (1998) and Nebout et al. (1999)

Department of Geography, University of Reading, UK

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2.1 Introduction

The Mediterranean Sea was once part of a much larger ocean which encircled the Earth. This was the Tethys Ocean which existed c.200 × 10^6 years ago and which subsequently diminished in extent due to the convergent movement of the African and Eurasian plates. By c.65 × 10^6 years ago Tethys had contracted to become the Mediterranean Sea. Since then there have been episodes of drying and flooding, low and high salinity, low and high sea levels, and cold and warmth, as well as volcanic activity and earthquakes. Many of these events are linked with climatic change and/or tectonic activity. This dynamism is reflected in the ecological changes within the sea itself and in its encircling landmasses as well as its many islands. The environment of the last 65 × 10^6 years has thus been anything but uniform or stable. A particularly turbulent period of environmental change occurred during the last 2 × 10^6 years, approximating to the Quaternary period. As high latitudes experienced major advances of ice sheets and glaciers interspersed with warm interglacial stages, the Mediterranean Basin experienced substantial temperature changes on a similar cyclical basis. Forests, grasslands and shrublands, with associated fauna, underwent continual reassembly as temperatures rose and fell. As the present interglacial, the Holocene, opened c.12 ×10^3 years ago, temperatures ameliorated and the ecosystems which characterize the present began to assemble. However, the Holocene is unique insofar as a new agent of environmental change began to transform landscapes. The population of modern humans (*Homo sapiens*) was expanding from ice-age refugia (Sykes 2001) and appropriating the resources of the Mediterranean Basin first as hunter-gatherers and later as agriculturalists. The environment and ecosystems of this region hardly had time to reassemble their interglacial characteristics before there was an onslaught by this new, cultural driver of environmental change. This onslaught continues today as agriculture, industry, tourism, pollution, urbanization, rural depopulation and introduced plants and animals exact their tolls. All of these natural and cultural factors have affected the Mediterranean Islands to some degree.

2.2 The Pre-Quaternary Setting

The supercontinent of Pangea, in which all the continents were joined, came into existence by c.250 × 10^6 years ago during the Permian period at the end of the Palaeozoic era. By c.200 × 10^6 years ago it was beginning to break up: the continent of the Americas drifted west and the Atlantic Ocean came into existence, and the African and Eurasian plates became separated with the formation of the Tethys Ocean between them. By c.100 × 10^6 years ago the Tethys was reducing in size as the Eurasian and African plates began to converge; within c.40 × 10^6 years the great Tethys had been reduced to a mere remnant: the Mediterranean Sea.

Evidence for subsequent environmental change derives from sediment cores collected from various locations within the Mediterranean Sea (e.g. Spezzaferri et al. 1998) and from terrestrial sedimentary sequences such as those on Sicily. Amongst the more extreme events recorded are the so-called Messinian salinity crisis and the later reopening of the link between the Mediterranean and the Atlantic Ocean via the Straits of Gibraltar. The Messinian event, widely acknowledged as a major geological event, began almost 6×10^6 years ago at the end of the Miocene epoch (Cenozoic era). By this time the connection with the Atlantic Ocean via the Strait of Gibraltar had been closed. There are conflicting views as to how the closure occurred and in relation to the rapidity of its occurrence. The former has been discussed by Duggen et al. (2003) who suggest a closure due to volcanic activity rather than a glacial drop in sea level or tectonic uplift while Warny et al. (2003) advocate tectonic uplift as the primary cause. The debate about the speed of occurrence is reflected in the work of Butler et al. (1999), who indicate a period of c.1.5×10^6 between the earliest and latest evaporite deposition, which contrasts with the findings of Krijgsman et al. (1999) who believe that deposition was synchronous throughout the basin and date this sudden event at $5.96 \pm 0.02 \times 10^6$ years ago. The latter state that 'Isolation from the Atlantic Ocean was established between 5.59 and 5.33×10^6 years ago, causing a large fall in Mediterranean water level followed by erosion (5.59 to 5.50×10^6 years ago) and deposition (5.50 to 5.33×10^6 years ago) of non-marine sediments in a large "Lago Mare" (Lake Sea) basin'. This hydrological isolation of the Mediterranean resulted in high salinity and desiccation; vast and deep salt deposits accumulated under desert-like conditions in a basin well below the level of the other oceans and many species became extinct. Overall tectonic movements and volcanic activity created the topographical characteristics of this early Mediterranean Basin while the development of aridity was probably due to the 400,000-year component of the Earth's eccentricity cycle. The Messinian event was brought to a close after a period of c.600,000 years when the link with the Atlantic Ocean was re-established via the Strait of Gibraltar. According to Blanc (2002) this occurred through the erosion of a stream which 'managed water piracy from an ocean'. The Mediterranean Basin refilled with water from the Atlantic which brought with it cold water flora and fauna in contrast to its earlier history when links to the east with the Red Sea allowed in tropical and subtropical species.

By the onset of the Pliocene epoch (5.3 to 1.8×10^6 years ago) the relative climatic stability which had persisted globally during the Mesozoic era was replaced with instability and a general cooling trend in a world which continued to be warmer and more humid than at present. The reconstruction of Pliocene environments in the Mediterranean Basin has been undertaken by Suc et al. (1994) using data from more than 60 localities, including boreholes and outcrops with dating control and with a focus on pollen analysis (for pollen diagrams, see Suc 1984). They divide the Pliocene into three phases as follows:

A. 5.2 to 3.2 × 10^6 years

Deposits from this phase are many and varied because of the infilling of canyons created in the basin during the arid Messinian. The stratigraphy and pollen assemblages indicate a heterogeneous basin due to latitudinal range and local topography, climate, etc. Suc et al. (1994) identify six different units:

1. The Atlantic region: Subtropical trees, notably *Taxodiaceae*, and warm-temperate trees were predominant along with ericaceous shrubs. Humid conditions were prevalent and thermophilous species increased towards the warmer south.
2. The southern Mediterranean: Vegetation communities south of latitude 42 °N (c. latitude of Barcelona) comprised xerophytic species. These included desert-margin species such as *Lygeum, Calligonum, Nitraria, Neurad, Agavaceae*, etc. Tropical species were present but probably in low numbers in the southern basin, e.g. Sicily and Crete, as well as the southern mainland. Xerophytes which are present today were already established in Sicily. Temperature regimes and moisture availability were the major constraints on plant growth and the evidence points to the dominance of seasonally dry climates.
3. The north-west (Pyrenees to central Italy): Three forest belts developed in response to altitude. The lowest belt comprised Sequoia-type species, *Cathaya* and *Cedrus* dominated the middle belt with *Abies* and *Picea* at high altitudes. Xerophytes are not well represented in the scarce pollen records, leading Suc et al. (1994) to suggest that relatively cool and humid conditions prevailed in this northern part of the basin, possibly including Corsica and Sardinia.
4. The north-east region: Pollen analytical results show a predominance of warm-temperate forest species which alternated with grassland species. Temperatures were lower than in the northwest due to montane environments and the increase of xerophytes towards the south reflects a gradient of increasing dryness.
5. The Nile area: Savanna species were dominant and communities included some desert and tropical species reflecting its African hinterland.
6. Local swamp/wetland environments: Local to Portugal, Catalonia and Romania, wetlands were dominated by *Taxodium*-type, *Nyssa, Symplocos, Myrica* and *Cyrillaceae – Clethraceae.*

B. 3.2 to 2.6 × 10^6 years

The major subdivisions noted above continued to prevail in the middle Pliocene with some local variations. In southern France thermophilous species declined, possibly due to increasingly cold winters and increased seasonality. Such a cooling event is also suggested by the work of Bertoldi et al. (1989) on the basis of pollen analyses of sediments in Calabria, southern Italy and Sicily in which they also record the onset of glaciation at c.2.4 × 10^6 years BP.

C. 2.6 to 1.8 × 10^6 years

The onset of oscillating glacial–interglacial cycles globally is registered locally in the northern Mediterranean region by the alternation of steppe-type vegetation, including *Artemisia* and *Ephedra*, with forests dominated by warm-temperate species. There is little evidence of environmental change in the southern Mediterranean region with the exception of the Nile area; here pollen of *Compositae* increased in the herb-pollen spectra. The basal date of 2.6×10^6 years BP is in general agreement with other ocean-sediment records for the onset of the Plio-Pleistocene (the latter is the early Quaternary before the Holocene) ice ages; for example, Shackleton et al. (1984) determined that the earliest ice-rafted material in North Atlantic sediment cores is dated at c.2.6×10^6 years BP and more recently Haug et al. (2005) have determined that the onset of northern hemisphere glaciation was c.2.7×10^6 years ago. The cause is attributed to Milankovitch forcing, notably a growth in ice sheets when summer insolation and temperatures in polar regions are low. This gave rise to enhanced stratification in sub-Arctic Pacific waters during late summer causing an increase in sea-surface temperatures which also persisted into the autumn. This meant that the region provided an increased volume of water vapour which led to increased precipitation as snow over the northern region of North America; concurrently, winter sea-surface temperatures declined giving rise to increased floating ice. These factors together triggered the onset of the Plio-Pleistocene ice ages.

Additional information on Pliocene environments has been presented by Kroon et al. (1998) and Howell et al. (1998) based on sediment cores from the Eastern Mediterranean Sea, by de Kaenel et al. (1998) and Nebout et al. (1999) from the Western Mediterranean (see also Béthoux and Pierre 1999 for a commentary on cores from both areas). All cores contain sapropels which are laminated sediments rich in organic material whose origin has caused much speculation and research. The sedimentary record extends back at least 3×10^6 years during which time at least 80 sapropels were deposited. These muds are considered to reflect changing environmental conditions during the Plio-Pleistocene, notably shifts in the freshwater/saltwater balance which affects water density and mixing capacity. This balance reflects, in turn, climatic conditions including warming and cooling associated with oscillating warm and cold stages. When there are substantial increases in freshwater into a saltwater basin the mixing of surface and deep waters is impaired causing stratification. The deep layers become oxygen depleted resulting in restricted decomposition of the organic remains of dead plankton and other organisms which become incarcerated as sapropels. The variations in freshwater/saltwater balance would have been determined by inputs from rivers and the relative salinities of the Mediterranean Sea and Atlantic Ocean. Changes in the latter, due for example, to ice cap melting and dilution of salt water with freshwater, would also affect the Mediterranean. Such a possibility lends further support to the influence of Milankovitch astronomical forcing on pre-Quaternary Mediterranean environments, an influence which continued throughout the Quaternary. Indeed, Johnson (2002) has suggested that changing salinity in the Mediterranean, linked with Milankovitch cycles (see below), may have been a major trigger for the Plio-Pleistocene ice ages.

2.3 The Quaternary Period

The opening of the Quaternary period is defined in the Mediterranean Basin itself on the basis of the stratigraphic record at Vrica, Calabria, in southern Italy. Here, deep-water sediments include a claystone overlying a sapropel bed (see above for definition), a sedimentary change which is accompanied by a change in the fossil content. This shift, the boundary between the Pliocene, the last epoch of the Tertiary period, and the start of the Pleistocene, the first epoch of the Quaternary period, is dated at 1.81×10^6 years BP. Details of this boundary and events defining the onset of the Quaternary period worldwide are given in Van Couvering (2004). There is considerable evidence for the influence of Milankovitch astronomical forcing of climate throughout the Quaternary period worldwide (see Mannion 1997, 1999; Lowe and Walker 1997, for methods and details of reconstructions).

Milankovitch-forcing is determined by the pattern of the Earth's motion around the Sun, i.e. orbital parameters, which is caused by the gravitational effects of the other planets circling the Sun. Details are shown in Fig. 2.1. Overall, the amount of radiation from the Sun is generally constant per year but these orbital parameters cause fluctuations in the amount of solar energy received at specific latitudes and/or in the distribution of solar energy by latitude and by season. There are three periodicities. The first is variation in eccentricity, or ellipticity of the Earth's orbit around the Sun which has a periodicity of about 100,000 years. It is important because the furthest away from the Sun, the Earth is on its elliptical orbit the less heat it receives. This characteristic is considered to be a major factor in the waxing and waning of ice ages. The second is variation in obliquity, i.e. the tilt of the Earth's axis away from the orbital plane. This has a periodicity of c.41,000 years which is the time taken for the tilt of the Earth on its axis to rotate 21.8° and 24.4°. When the angle of tilt is at a minimum, i.e. 21.8°, incident radiation is c.15% less in the northern hemisphere than when the angle of tilt is at its maximum. Thus periods of minimum tilt are cooler than those of maximum tilt. Moreover, the greater the tilt the more severe are the seasons with increased summer warmth and intensified winter cold while less tilt gives rise to less severe seasons with cooler summers and milder winters. The latter is conducive to ice sheet accumulation because warmer winter air is able to hold more moisture, and so enhances snowfall volume, while cooler summer temperatures result in reducing the melting of the winter snow accumulation. The third periodicity concerns the precession of the equinoxes, with values of c.23,000–19,000 years. Precession is caused by two factors: a wobble of the Earth's axis, and a turning-around of the elliptical orbit of the Earth. Obliquity affects the tilt of the Earth's axis while the precession affects the direction of the Earth's axis. Shifts in the location of the axis alter the dates of perihelion, i.e. when the Earth is at its closest to the Sun, and aphelion, i.e. when the Earth is furthest from the Sun. Overall, this increases the seasonal contrast in one hemisphere and decreases it in the other hemisphere. If the northern hemisphere winter occurs when the Earth is furthest from the Sun and summer occurs when the Earth is closest to the Sun, seasonal contrasts will be enhanced encouraging ice sheet growth.

Evidence for environmental changes driven by Milankovitch cycles and other factors derives from a variety of sources: marine-sediment cores, lake sediments, raised beaches, soil profiles, volcanic ash (tephra) deposits and archaeological sites. The record of environmental change herein presented is based on mainland sites, because of the relative abundance of published work, as well as the islands where evidence is available. The environmental changes of the Quaternary period comprise

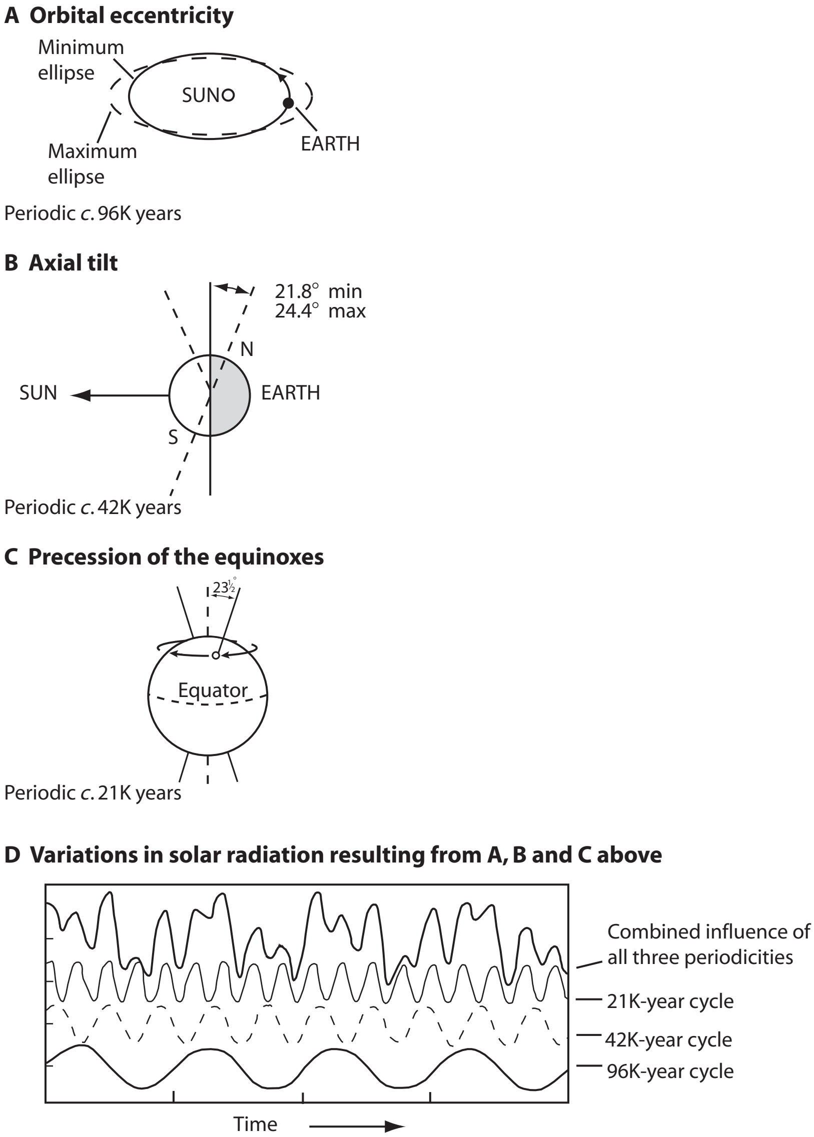

Fig. 2.1 The astronomical forcing factors involved in the Milankovitch theory (astronomical theory) of climatic change

ecosystem alteration involving plants, animals, refugia and soils; sea-level oscillations and the creation and severance of land bridges; volcanic activity and human occupation. The most complete record of early Quaternary environmental changes in the Mediterranean Basin occurs in marine sediments; the longest terrestrial deposits, in contrast, notably lake sediments, provide evidence for only the last

1 million years at most and occur in mainland Greece, Italy, Israel and France. There is abundant evidence for the Holocene epoch, the last c.10,000 years, including direct evidence from the Mediterranean Islands themselves.

2.3.1 The Record in Marine Sediments

The marine sediment cores referred to above, from the East and West Mediterranean, provide a record of environmental change for the Quaternary period in two main ways: oxygen-isotope stratigraphy and fossil content. The rationale of the former is described in Fig. 2.2 which reflects the link between isotope concentrations and global temperatures and ice volume. The oxygen-isotope records of both cores are given in Fig. 2.3 and show that there were more than 60 stages during the last 1.6 to 1.8×10^6 years. Overall, and in light of the fact that warm and cold stages are represented by odd numbers and even numbers respectively, this was a period of tremendous climatic change with temperatures dropping by as much as 10 °C during cold stages. On the basis of the oxygen-isotope stratigraphy of two cores from the Strait of Sicily, Howell et al. (1998) show that three major periods of cooling occurred c.2.6, 0.98 and $0.46/0.45 \times 10^6$ years BP in tandem with increases in global ice volume. Kroon et al. (1998) also note that fluctuations in the oxygen-isotope record are chiefly influenced by obliquity and precessional forcing (Fig. 2.1) for the first part of the Quaternary (and earlier Pliocene) until 1×10^6 years ago. Thereafter all astronomical forcing periodicities are registered. Not all warm stages are interglacials; some are relatively short-lived warm intervals known as interstadials which punctuate ice ages or stadials. There are also strong relationships between these stages and sapropel formation (see above), especially with the precessional cycle, a major influence on monsoonal climates and thus of freshwater influx especially from the Nile. The strong obliquity signal until c.1×10^6 years BP reflects synchroneity with the intensification of high-latitude glacial–interglacial cycles.

These shifts are also reflected in other characteristics of the marine sediments, notably fossil content. For example, in the core from Ocean Drilling Program site 976 in the Alboran Sea (between Spain and Morocco) changes in relative abundances of dinoflagellate cysts, the remains of microscopic, mostly unicellular protists (often referred to as algae) of planktonic habit, and the species composition parallel oxygen-isotope fluctuations (Nebout et al. 1999). This is considered to reflect changes in surface-water temperatures. Moreover, substantial changes in assemblages indicate that a major event occurred c.0.7×10^6 years BP due to significant climatic and/or hydrological change. The pollen content of these cores was also analysed and provides a surrogate for vegetation change in nearby landmasses of southern Spain and North Africa. The inferences may also apply to the Balearic Islands. The pollen assemblages range between those of semi-desert communities to those of coniferous and deciduous forests; the former dominate cold stages characterized by aridity while coniferous and then deciduous forests develop during warm stages. This contrasts with the pollen analyses of the Hula Basin, Israel, which is indicative of the Eastern Mediterranean as discussed in Section 2.3.2.

The principles of oxygen-isotope analysis

1. The carbonated secreted in the calcareous shells of marine organisms such as foraminifera contains two isotopes of oxygen: ^{18}O and ^{16}O. The ratio in which these occur depends on water temperature and the average of 1 ^{18}O:500 ^{16}O. Similarly, ice caps comprise water with a proportion of ^{18}O. Oxygen-isotope stratigraphy is thus characteristic of both fossil marine organisms such as foraminifera and polar ice cores.
2. The ratios are measured in relation to a standard, and are recorded as the deviation of ^{18}O from this standard. For carbonate shells, the standard is derived from PDB, a Cretaceous belemnite from the Pee Dee Formation in North Carolina, USA. For ice, water and snow, the standard is derived from Standard Mean Ocean Water (SMOW).
3. Mass spectroscopy is used to determine the volumes of each isotope in a given sample. Oxygen isotope ratios are calculated as positive or negative values relative to the standard, using the following equation:

$$\delta^{18}O = 1000 \times \frac{^{18}O/^{16}O\text{sample} - ^{18}O/^{16}O\text{standard}}{^{18}O/^{16}O\text{standard}}$$

4. The deviation from the standard is an indicator of temperature and global ice volume. This is because fractionation occurs between the two isotopes. The ^{16}O is the lighter of the two, so that water containing ^{16}O ($H_2{}^{16}O$) is preferentially evaporated; this process is temperature-dependent. The more $H_2{}^{16}O$ that evaporates the more the remaining seawater becomes $H_2{}^{18}O$ enriched. The $^{16}O/^{18}O$ characteristics of the seawater are reflected in the carbonate of the foraminifera shells. Moreover, winds carry $H_2{}^{16}O$-enriched water vapour from the oceans to the poles, where it eventually becomes trapped as ice. Consequently, the ice contains an oxygen isotope signal that is the mirror image of that in ocean sediments.
5. During ice ages, $H_2{}^{18}O$ became enriched in the oceans and hence in the foraminifera while ice caps became enriched in $H_2{}^{16}O$. During interglacials, much of the $H_2{}^{16}O$ stored in the ice was released, diluting $H_2{}^{18}O$ in the oceans and causing a shift in the ratio. Variations in the ratio for the last 3×10^6 years in two cores from the East and West Mediterranean Basin are given in Fig. 2.3.

Fig. 2.2 The principles of oxygen-isotope analysis (Based on Mannion 1999)

Insofar as compression of sediments occurs because of accumulation, sediment cores provide a clearer picture of recent rather than older environmental change. Cores from the Mediterranean Sea thus provide considerable detail on the last climatic cycle involving a glacial and interglacial stage, i.e. from c.150,000 years BP to present. While Milankovitch forcing factors (Fig. 2.1) provide a partial rationale for overall climatic change, marine-sediment cores provide opportunities for detailed reconstruction of the shift from the cold to warm, and vice versa. Many ODP Mediterranean and other cores yield a detailed record of the shift from last interglacial to present interglacial conditions. For example, Sprovieri et al. (2003) have reported on planktonic foraminifera and calcareous nanofossils from ODP core site 963D which is located in the Sicily Strait. The variations in the fossil assemblages for the period 23,000–1,500 BP reflect minor and major climatic changes in agreement with polar ice core data; amongst the latter is the shift from last glacial to interglacial (Holocene) conditions. Recent work by Hayes et al. (2005) based on the temperature preferences of planktonic foraminifera from 145 Mediterranean core samples indicates that substantial temperature gradients occurred from east to west during the Last Glacial Maximum. The data reflect a temperature gradient of 9 °C during the glacial summer and 6 °C in winter, both being c.4 °C greater than the respective temperature gradients at present, and suggest cooler sea-surface temperatures than other studies.

In common with other Mediterranean cores, the evidence indicates that the later Holocene was a period of climatic variability rather than stability. Bucceri et al.(2002) and Sbaffi et al. (2004) report similar findings from a core from the Tyrrhenian Sea; as well as Termination I which marks the end of the last stadial the planktonic foraminifer stratigraphy reflects seven cold episodes during the Holocene, with each lasting between 400 and 1,000 years. Pollen assemblages from the Eastern Mediterranean, and especially the presence of *Pistacia* which reflects lack of winter frost, have led Rossignol-Strick (1999) to suggest that the early Holocene was the post-glacial climatic optimum with high moisture and mild winters. Moreover, Kallel et al. (2003) note that in the eastern Levantine basin climate became drier and similar to that of the present c.7,000 years ago but in the western Tyrrhenian Basin this occurred c.5,000 years ago. Such climatic oscillations would have affected ecosystem dynamics on the Mediterranean Islands, details of which are discussed below.

A record of volcanic eruptions is also present in marine sediments as demonstrated by Iorio et al. (2004) who present records of petrophysical and palaeomagnetic measurements from three cores from the Salerno Gulf (southern Italy). As well as noting major changes at 7,000 years BP, which correlates with the results of Kallel et al. (2003) referred to above, Iorio et al. (2004) recorded a pumice layer formed by an eruption of Vesuvius and dated to AD 79. Two further volcanic ash layers dated to 1,300 and 3,000 years ago attest to additional volcanic activity, probably by Vesuvius. Such eruptions would have affected flora and fauna, at least in the vicinity of Vesuvius and probably Sicily. In addition, many Mediterranean cores from sea and land contain a pumice/ash layer equating to the massive eruption of Santorini. This occurred c.1630 BC and is linked, controversially, with the demise of the Minoan civilization (Friedrich 2000); its effect and that of related tsunamis would have been felt throughout the Mediterranean Basin albeit for a limited period.

2.3.2 The Pollen Record from Lake Sediments

There is a considerable body of pollen analysis for the Mediterranean Basin as a whole (see Allen 2003, for a partial review) but only a few diagrams for the islands from where none extend back to the last glacial. Only pollen spectra from sections on southern Sicily (Bertoldi et al. 1989; see Section 2.2), comprising marine sediments, provide evidence of pre-Holocene environments. On the mainland there are several long pollen sequences, with the longest, from the Hula Basin in Israel, extending back c.3.5×10^6 years. These provide considerable insight into the dynamics of Mediterranean plant communities as they responded to repeated climatic cooling and warming; they also facilitate comparison and correlation with polar ice and marine sediment cores and thus contribute to the understanding of global environmental change.

The pollen assemblages in the deep core from the Hula Basin, Israel (Horowitz 1989), reflect intense cooling between 2.4 and 2.6×10^6 years ago, in general agreement with the evidence from marine-sediment cores (see above). During the Quaternary period the many climatic cycles show a succession comprising oak and pine forest followed by maquis and then steppe vegetation. The forests were characteristic of cold/glacial stages when temperatures were lower but precipitation was higher than at present; the maquis communities were transitional to interglacial steppe vegetation characteristic of hot and dry climates similar to present. Interstadial periods in this region were also wetter than at present, especially during the winter. Such conditions probably characterized the Eastern Mediterranean in general, in contrast to the Western Mediterranean where the succession from cold to warm involved shifts from shrub/grassland to coniferous and then deciduous woodland (see Section 2.3.1).

The 196 m sediment core of Tenaghi-Philippon in eastern Macedonia, Greece covers the last 975,000 years (Mommersteeg et al. 1995); the pollen assemblages reflect Milankovitch orbital frequencies (see Fig. 2.1). The data from the upper c.500,000 years have been compared with other long cores in the Mediterranean region, notably Lac du Bouchet/Praclaux located in the Massif Central of France (Reille et al. 1988; Reille and de Beaulieu 1995),Valle di Castiglione in central Italy (Folieri et al. 1988; Magri 1989), and Ioannina in north-west Greece (Tzedakis 1993), to determine regional trends in vegetation/climatic change in relation to Milankovitch forcing frequencies (Tzedakis et al. 1997, 2003), and to establish a bio-chronostratigraphical framework for southern Europe (Tzedakis et al. 2001). A high degree of agreement exists between the sites, and between the sites and marine oxygen-isotope records, reconfirming a synchroneity which reflects overall climatic control on ecosystem dynamics. In general the stadials were dominated by steppe communities which included *Artemisia* and *Chenopodiaceae* and were punctuated by warmer but relatively short-lived periods known as interstadials. These were sufficiently warm with enough precipitation to support deciduous woodland similar to that of the present interglacial. Between the stadials are interglacials of c.10, 000–15,000-years duration. These are characterized by an increase in first birch (*Betula*) and juniper (*Juniperus*), followed by oak (*Quercus*), elm (*Ulmus*), lime (*Tilia*) and hazel (*Corylus*) and later increases in hornbeam (*Carpinus*), beech (*Fagus*) and fir (*Abies*). There are local variations in terms of timing but overall the interglacial succession appears to be more similar to that recorded in the sediment core from the Alboran Sea, Western Mediterranean (see Section 2.3.1) than to the succession of the Hula Basin. This reflects increasing continentality to the east. Pollen assemblages from Lake Kopais in south-east Greece show similar developments (Okuda et al. 2001; Tzedakis 1999). Moreover, Allen (2003) makes the points that many vegetation changes are relatively abrupt following climatic amelioration or deterioration and that the terrestrial sites investigated appear to be more sensitive indicators of environmental change than marine sites.

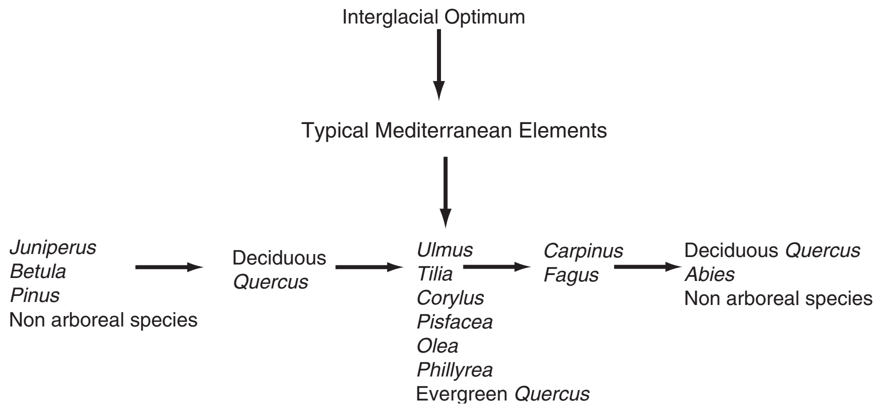

Fig. 2.3 Schematic representation of interglacial vegetation succession in the Mediterranean Basin (Based on publications quoted in the text)

Much attention has been given to the last few interglacial periods, because they provide a record uninterrupted by human activity and thus reflect natural change in response to climatic forcing, and because they provide a record of an entire interglacial in contrast to the much-modified and only partly completed Holocene. The deep cores referred to above contain a record of at least the oxygen-isotope stages 9–1 and some contain a record of stages 11–1 (see Fig. 2.3 for oxygen-isotope stages). Stages 9–1 include the Holocene (stage 1) and three earlier interglacials; stages 11–1 include an additional earlier interglacial. All show a consistent pattern of mixed forest development dominated by oak (*Quercus*) with a variety of elements which are distinctly Mediterranean in character. A schematic representation is given in Fig. 2.3. The Hula Basin, Israel, is the exception: forests are characteristic of cold rather than warm stages which are dominated by steppe communities. Comparisons have also been made with interglacial deposits elsewhere in Europe; for example, Tzedakis et al. (2003) show that the length of the last interglacial at Ioannina, north-west Greece, as defined by the presence of forest, lasted c.15,000 years as compared with c.10,000 years (the Eemian interglacial) in north-west Europe. This persistence of forests into oxygen-isotope stage 5d, when ice accumulation was accelerating in polar regions, is attributed to continued warmth in the central North Atlantic by Kukla et al. (2002). This continued until subsequent pulses of cold water began, c.107,000 years ago, the same time as the Mediterranean forests disappeared rapidly.

If forests dominated much of the Mediterranean Basin during interglacials what happened during the cold stages? Although cold stages lasted c.100,000 years, they were not uniform; punctuating interstadials (see Section 2.3.1) of c.2,500 and 6,500 years brought climatic conditions of considerable warmth. This encouraged rapid forest growth which persisted after the return of cold conditions. Efforts have also been made to reconstruct world vegetation cover for the last glacial maximum c.18,000 years ago (e.g Adams and Faure 1997; see also Ray and Adams 2001).

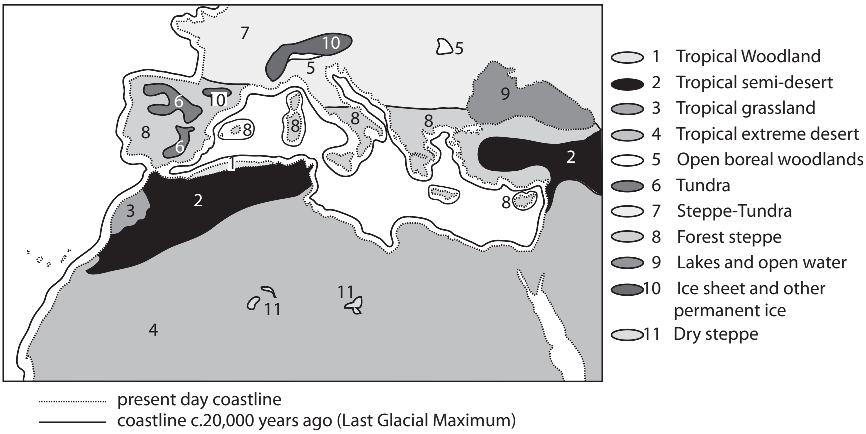

Fig. 2.4 Reconstructed vegetation cover for the Mediterranean Basin c.18,000 ago (Based on Adams and Faure 1997)

Fig. 2.4 shows the vegetation at 18,000 years BP in Europe and North Africa. While ice covered the Alps and much of north-west Europe including the British Isles, steppe vegetation dominated the Mediterranean region, including the Balearics, Corsica and Sardinia; the latter were also joined by a land bridge. In North Africa, a band of Mediterranean sclerophyllous scrub was present along the coast of Morocco while semi-desert grassland/shrubland or desert characterized the rest of the southern basin. Conditions in Malta, Cyprus and Crete cannot be determined but in view of the dominance of relatively arid conditions they too would have carried a vegetation cover of grassland or semi-desert. A similar reconstruction is detailed by Elenga et al. (2000).

Pollen analysis has also generated information about the transition stages between stadials and interglacials, as the papers referred to above attest. Information pertaining to the last transition reveals a complex pattern of climatic and associated ecological change during a period known as the late glacial which is a prelude to the Holocene.

Only one island pollen diagram from Corsica contains a record of the late glacial period (Reille et al. 1997); otherwise information is available from marine-sediment cores (see Section 2.3.1) and from pollen diagrams from the mainland. For example, Lawson et al. (2004) provide details of the late glacial at Ioannina, north-west Greece. A summary of the data from Creno Lake, Corsica is given in Table 2.1. As Reille et al. (1997) point out, the site is important not least because it provides an insight into the history of *Pinus nigra* spp. *larico* which seems not to appear in the lake catchment until the Holocene. Although distant, the Ioannina record (Lawson et al. 2004) reflects a strong expansion of temperate woodland during the Allerød which did not diminish significantly with the onset of the colder Younger Dryas. This comparison may indicate a more rapid colonisation of trees from the west. It also raises the issue of refugia which are thought to have existed in the Iberian and Italian and southern Balkan peninsulas, at least for deciduous *Quercus* species (see also comments by

Table 2.1 A summary of late-glacial pollen assemblages from Lake Creno, Corsica (Based on Reille et al. 1997)

Zone	Basal date ^{14}C years BP	Vegetation characteristics
Holocene	10,036 ± 85	Substantial decline in *Artemisia*; marked increase in *P. nigra spp. larico* indicating its arrival locally.
Younger Dryas	11,440 ± 150	*Artemisia, Chenopodiaceae* etc. expand and trees decline as climate deteriorates.
Allerød	12,520 ± 100	*Artemisia* declines as moister conditions develop. Trees are present, e.g. *Betula pendula* and *Alnus viridis* spp. *suaveolens, Quercus ilex* and *Tilia*. A surprising lack of increase in *P. nigra* raises questions about its local status. Vegetation belts appear to have been c.500 m lower than at present.
Lower Late glacial	14,560 ± 100	Abundant *Artemisia* occurs as a rich steppe-flora develops consisting of *Chenopodiaceae* and *Poaceae* plus other herbs (e.g. *Ephedra, Apiaceae* and *Compositae*) and xerophytes. The presence of trees is doubtful. *Pinus nigra* spp. *larico* pollen is present in only small quantities and may have been blown in. Only *Juniperus communis* may have been local.
Last stadial (Würm in NW Europe)	75,000	Substantial increase in *Artemisia* in common with other south European sites marks end of zone. Tree pollen is sparse and was probably derived from extra-island sources (e.g. *Cedrus* from North Africa) along with some types of herb pollen.

Allen 2003). Genetic data (Petit et al. 2002) for several species of *Quercus alba* and other deciduous trees and shrubs (Petit et al. 2003) lend weight to these suggestions which are based on palynological data. According to Brewer et al. (2002), the spread of *Quercus* from refugia occurred in two waves: the late glacial interstadial (Allerød) when a movement to the central European mountains occurred, and a second spread with the opening of the Holocene which culminated in a pan-European distribution. The first expansion is attributed primarily to climatic amelioration and the second expansion to interspecies competition, topography and soil conditions. There is little evidence to suggest whether glacial refugia were present on any of the Mediterrannean Islands; the possibility of Corsica as a refuge for *Erica arborea* is referred to below. Lack of evidence does not necessarily mean lack of refugia.

There is a considerable body of pollen analysis relating to the Holocene of the Mediterranean Basin. Most is from mainland sites but lake sediments from Corsica, the Balearics, Sicily and Crete have yielded valuable insights into floristic and landscape change during the last 10,000 years. There is, however, a dearth of information for Sardinia, Malta and Cyprus. The available data reflect some common development but also many variations. First, forest cover begins to be reinstated in the early Holocene when climatic conditions were different to those characteristic of today's Mediterranean region. Interestingly, Bottema and Sarpaki (2003) state that the period c.9,000–c.7,500 years BP was the driest of the entire Holocene for Crete while Sadori and Narcisi (2001) indicate that Sicily contemporaneously experienced the wettest conditions of the Holocene. This appears to be a surprising juxtaposition but it is also the case for the coastal plain of Israel (Gvirtzman and Wieder 2001) and in the Balearics (Yll et al. 1997) where Holocene vegetation change is markedly different from that of mainland Spain. Reille et al. (1999) draw attention to the lack of *Quercus* and *Corylus* in the early Holocene of Corsica and the possibility that *Erica arborea* may have persisted in refugia from whence it expanded following Holocene warmth. All the pollen diagrams reflect human impact on the vegetation at different times. This is discussed further in Chapter 3.

2.3.3 Other Lines of Evidence: Palaeosols, Speleothems, Geomorphology, Fossil Fauna, etc.

Other types of evidence from Mediterranean Islands bear witness to the environmental changes of the Quaternary; they complement, question or reinforce evidence from marine and lake sediments. Study sites are concentrated on Crete, Sicily, Corsica and the Balearics.

For example, the deposition of aeolian material on a wave cut platform in southern Mallorca is shown by Nielsen et al. (2004) to have occurred in a period of alternating warm/moist and cold/dry conditions following isotope stage 1. This was an interglacial stage when the platform was cut by wave action during a period of raised sea level. Another example comprises sediment and soil sequences in the coastal zone of north-east Mallorca (Rose et al. 1999) which provide a record of the last 140,000 years. The interpretation, based on geological structures, molluscan fauna, grain size, mineral magnetics, geochemistry, amino acid stratigraphy and oxygen-isotope values, is summarized in Table 2.2. The data highlight temperature ranges between interglacials and cold stages.

These data generally reinforce the findings from mainland sites in France, Italy and Spain and those from marine sediments. Speleothems, e.g. stalagmites and stalactites, are also present in Mallorcan caves; their U-series (Uranium series) and oxygen isotope characteristics provide information on environmental and sea-level change. One such study is that of Vesica et al. (2000) whose analyses show that elevated sea levels during oxygen isotope stages 9, 7, 5e, 5c and 5a, all of which are interglacial or interstadial stages when global ice volume was reduced. This oscillation of global ice volume is also reflected in the glacial and periglacial deposits present in Mediterranean mountains (see review by Hughes et al. 2006) where the most extensive glaciations occurred between c.400,000 and 127,000 years ago. Evidence is particularly strong in Italy, Greece and Iberia; on the islands glacial deposits are noteworthy on Corsica where there is possibly evidence for four glacial stages (Hughes et al. 2006).

Given the evidence for substantial change in vegetation communities during the Quaternary period there were also major changes in the fauna, though there

Table 2.2 Summary of environmental changes in north-east Mallorca during the last 140,000 years (Based on Rose et al. 1999)

Oxygen isotope stage	Mean annual temperatures	Environmental characteristics
1	Up to 17.3 °C	Some landscape instability in the early stage
2	8.1 °C	Limited vegetation cover, active aeolian and slope processes, fluvial fan deposition; cold arid conditions
3	13 °C	Loess deposition continued in the early stage but increasing humidity and higher temperatures favoured vegetation and soil development
4	4.9 °C	Active aeolian sand and loess deposition, poor soil development, some fluvial activity; extreme cold
5a	17.9 °–10.3 °C	High sea level; cool-temperate moist conditions
B	10.8 °–6.7 °C	Cooling, vegetation disruption, wind/water erosion; sediment deposition
C	17.9 °C–13.6 °C	Moist cool temperate climate; soil formation, dust in atmosphere, loess deposition; open vegetation
D	13.6 °C–8.2 °C	Cooling; disruption of vegetation cover, wind/water erosion
E	19.5 °C–11.3 °C	Interglacial Mediterranean-type soils, stable landscape with continuous vegetation cover; strong weathering in seasonally moist climate
6	10.2 °C	Cold; aeolian deposition of dunes, arid conditions, sparse vegetation

is much less evidence for this. The review by Blondel and Aronson (1999) is concerned chiefly with the mainland of Mediterranean Basin rather than the islands. They state ‘In the Middle Pleistocene (1 Myr BP), a major faunal turnover, associated with large climatic cycles with long-lasting cold episodes, was characterized by the disappearance of all tropical species, the extinction of many ancient boreal species, the arrival of “cold faunas” of boreal origin, and finally the settling-in of modern faunas’. This must have occurred on the islands but detail is sparse. There is some information on the ancient faunas of the Balearic Islands where distinctions in between the endemic mammal and bird faunas of the Gymnesic and Pityusic island groups have been noted by Palmer et al. (1999) who attribute it to the existence of land bridges within but probably not between the groups. Fattorini (2002) also suggests that land bridges during cold stages of the Quaternary facilitated dispersal of the tenebrionid beetle fauna of the Aegean Islands but that distinct differences between the eastern and western islands indicates the absence of any former land bridges between these two island groups. According to Masseti (1995) few carnivores were present on any island during the Quaternary period; one exception is the otter (*Lutra lutra*); fossils of other mustelids occur but they are not related to modern species which Masseti believes were introduced by humans.

There is evidence for gigantism and dwarfism in some island mammals during the Quaternary period (see discussion in Burness et al. 2001). Dwarfism occurs in some island contexts because it confers some evolutionary advantage, including

Table 2.3 Dwarf and giant animals of Mediterranean Islands (Based on Attenborough 1987)

Islands	Animals
Sicily	Pigmy Elephant, Pigmy Hippo, Giant Dormouse
Sardinia	Small Macaque, Large Rodents, Large Shrews, Pigmy Hippo, Pigmy Elephant, Pig, Dwarf Deer, Pigmy Elephant, Pigmy Hippo, Giant Dormouse
Cyprus	Pigmy Elephant, Pigmy Hippo
Corsica	Large Shrews, Large Rodents, Dwarf Deer
Crete	Pigmy Elephant, Pigmy Hippo, Dwarf Deer, Large Rodents
Mallorca/Minorca	Myotragus, Giant Dormouse, Giant Shrew
Malta	Pigmy Elephant, Pigmy Hippo, Dwarf Deer, Giant Dormouse
Rhodes, Tilos, Dilos, Naxos	Pigmy Elephant, Pigmy Hippo, Dwarf Deer, Large Rodents

reduced resource requirements and improved shelter from prey if trees are absent. Where resources are less limited gigantism confers advantage over predators. Table 2.3 gives details of Quaternary faunal elements with either condition on the Mediterranean Islands. Details of a fossil dwarf caprine (*Myotragus balearicus* Bate 1909) from the Gymnesic Islands have been presented by Bover and Alcover (2003) while the more well-known dwarf mammals are the elephant and hippopotamus. According to Palombo (2003) the smallest fossil elephants are found in Sicily in deposits of Middle Quaternary age and there is some debate as to the true ancestor; the three possibilities are *Elephas, Mammuthus* and *Loxodonta*. Palombo suggests that they derive from *E. antiquus*. A survey of the fossil 'elephants' from Crete by Poulakakis et al. (2002) reveals two groups of fossils representing fossils of the pygmy form of *Mammuthus creticus* and the large form of *Elephas antiquus creutzburgi*. The former lived on Crete from the early Quaternary to the beginning of the middle Quaternary, and the latter prevailed from the end of the Middle Quaternary to the late Quaternary. The data of Table 2.3 imply that variations from mainland animals were considerable and that the faunas of the past were quite different to those present in the islands today.

2.4 Conclusion

The environment of the Mediterranean Islands since the Messinian salinity event has undergone tremendous and continuous change. Flora, fauna, ecosystems and soils have responded to the repeated cooling and warming of the Tertiary/Quaternary climatic cycles, evidence for which derives from a variety of sources. As new evidence unfolds the mosaic of past environments and their response to climatic forcing will become increasingly detailed. The Holocene brought the environmental characteristics which are familiar today but it also brought a new and powerful agent of environmental change: *Homo sapiens*, the impact of which is examined in Chapter 3.

References

Adams, J.M. and Faure, H. (1997) Preliminary vegetation maps of the world since the last glacial maximum: an aid to archaeological understanding. Journal of Archaeological Science 24: 623–647.

Allen, H.D. (2003) Response of past and present Mediterranean ecosystems to environmental change. Progress in Physical Geography 27: 359–377.

Attenborough, D. (1987) The First Eden: The Mediterranean World and Man. Little Brown: Boston, MA.

Bertoldi, R., Rio, D. and Thunell, R. (1989) Pliocene-Pleistocene vegetational and climatic evolution of the south-central Mediterranean. Palaeogeography, Palaeoclimatology, Palaeoecology 72: 263–275.

Béthoux, J.-P. and Pierre, C. (1999) Mediterranean functioning and sapropel formation: respective influences of climate and hydrological changes in the Atlantic and the Mediterranean. Marine Geology 153: 29–39.

Blanc, P.-L. (2002) The opening of the Plio-Quaternary Gibraltar strait: assessing the size of a cataclysm. Geodinamica Acta 15: 303–317.

Blondel, J. and Aronson, J. (1999) Biology and wildlife of the Mediterranean region. Oxford University Press: Oxford.

Bottema, S. and Sarpaki, A. (2003). Environmental change in Crete: a 9000-year record of Holocene vegetation history and the effect of the Santorini eruption. The Holocene 13: 733–749.

Bover, P. and Alcover, J.A. (2003) Understanding late Quaternary extinctions: the case of *Myotragus balearicus* (Bate, 1909). Journal of Biogeography 30: 771–779.

Brewer, S., Cheddadi, R., de Beaulieu, J.-L., Reille, M. and Data contributors. (2002) The spread of deciduous Quercus throughout Europe since the last glacial period. Forest Ecology and Management 156: 27–48.

Bucceri, G. et al. (2002) A high resolution record of the last deglaciation in the southern Tyrrhenian Sea: environmental and climatic evolution. Marine Geology 186: 447–470.

Burness, G.P., Diamond, J. and Flannery, T. (2001) Dinosaurs, dragons, and dwarfs: the evolution of maximal body size. Proceedings of the National Academy of Sciences 98: 14518–14523.

Butler, R.W.H., McClelland, E. and Jones, R.E. (1999) Calibrating the duration and timing of the Messinian salinity crisis in the Mediterranean: linked tectonoclimatic signals in thrust-top basins in Sicily. Journal of the Geological Society 156: 827–835.

Duggen, S., Hoernie, K., van den Bogaard, P., Rupke, L. and Phipps Morgan, J. (2003) Deep roots of the Messinian salinity crisis. Nature 422: 602–605.

Elenga, H. et al. (2000) Pollen-based biome reconstruction for southern Europe and Africa 18,000 yr BP. Journal of Biogeography 27: 621–634.

Fattorini, S. (2002) Biogeography of the tenebrionid beetles (Coleoptera, Tenebrionidae) on the Aegean Islands (Greece). Journal of Biogeography 29: 49–67.

Folieri, M., Magri, D. and Sadori, L. (1988) 250,000-year pollen record from Valle di Castiglione (Roma). Pollen et Spores 30: 329–356.

Friedrich, W.L. (2000) Fire in the sea: volcanism and the natural history of Santorini. Cambridge University Press: Cambridge.

Gvirtzman, G. and Wieder, M. (2001) Climate of the last 53,000 years in the eastern Mediterrannean, based on soil-sequence stratigraphy in the coastal plain of Israel. Quaternary Science Reviews 20: 1827–1849.

Haug, G.H. et al. (2005) North Pacific seasonality and the glaciation of North America 2.7 million years ago. Nature 433: 821–825.

Hayes, A., Kucera, M., Kallel, N., Sbaffi, L. and Rohling, E.J. (2005) Glacial Mediterranean sea surface temperatures based on planktonic foraminiferal assemblages. Quaternary Science Reviews 24: 999–1016.

Horowitz, A. (1989) Continuous pollen diagrams for the last 3.5Ma from Israel: vegetation, climate and correlation with the oxygen isotope record. Palaeogeography, Palaeoclimatology, Palaeoecology 7: 63–78.

Howell, M.W., Thunell, R.C., Di Stefano, E., Sprovieri, R. Tappa, E.J. and Sakamoto, T. (1998) Stable isotope chronology and paleoceanographic history of sites 963 and 964, Eastern Mediterranean Sea. Proceedings of the Ocean Drilling Program, Scientific Results 160: 167–180.

Hughes, P.D., Woodward, J.C. and Gibbard, P.L. (2006) Quaternary glacial history of the Mediterranean mountains. Progress in Physical Geography 30: 334–364

Iorio, M., Sagnotti, L., Angelino, A., Budillon, F., D'Argenio, Dinarès-Turell, J., Macri, P. and Marsella, E. (2004) High-resolution petrophysical and palaeomagnetic study of late-Holocene shelf sediments, Salerno Gulf, Tyrrhenian Sea. The Holocene 14: 426–435.

Johnson, R.G. (2002) Secrets of the Ice Ages: The Role of the Mediterranean Sea in Climate Change. Glenjay Publishing: Minnetonka, MN.

de Kaenel, E., Siesser, W.G. and Murat, A. (1998) Pleistocene calcareous nannofossil biostratigraphy and the Western Mediterranean sapropels, Sites 974 to 977 and 979. Proceedings of the Ocean Drilling Program, Scientific Results 161: 159–183.

Kallel, N., Duplessy, J.-C., Labeyrie, L., Gasse, F., Fontugne, M. and Paterne, M. (2003) Mediterranean Sea palaeohydrology and pluvial periods during the upper Quaternary. Geophysical Research Abstracts 5: 12417.

Krijgsman, W., Hilgen, F.J., Raffi, I., Sierro, F.J. and Wilson, D.S. (1999) Chronology, causes and progression of the Messinian salinity crisis. Nature, London 400: 652–655.

Kroon, D., Alexander, I., Little, M., Lourens, L.J., Matthewson, A., Robertson, A.H.F. and Sakamoto, T. (1998) Oxygen isotope and sapropel stratigraphy in the Eastern Mediterranean during the last 3.2 million years. Proceedings of the Ocean Drilling Program, Scientific Results 160: 181–189.

Kukla, G.J. et al. (2002) Last interglacial climates. Quaternary Research 58: 2–13.

Lawson, I., Frogley, M., Bryant, C., Preece, R. and Tzedakis, P. (2004) The Lateglacial and Holocene history of the Ioannina basin, north-west Greece. Quaternary Science Reviews 23: 1599–1625.

Lowe, J.J. and Walker, M.J.C. (1997) Reconstrucing Quaternary Environments. Longman: Harlow, UK.

Magri, D. (1989) Interpreting long-term exponential growth of plant populations in a 250,000-year pollen record from Valle di Castiglione (Roma). New Phytologist 112: 123–128.

Mannion, A.M. (1997) Global Environmental Change, 2nd edn. Longman: Harlow, UK.

Mannion, A.M. (1999) Natural Environmental Change. Routledge: London.

Masseti, M. (1995) Quaternary biogeography of the mustelid family on the Mediterranean Islands. Hystrix 7: 17–34.

Mommersteeg, H.J.P.M., Loutre, M.F., Young, R. Wijmstra, T.A. and Hooghiemstra, H. (1995) Orbital forced frequencies in the 975,000 year pollen record from Tenaghi Philippon (Greece). Climate Dynamics 11: 4–24.

Nebout, N.C., Londeix, L., Baudin, F., Turon, J.-L., von Grafenstein, R. and Zahn, R. (1999) Quaternary marine and continental paleoenvironments in the Western Mediterranean (site 976, Alboran Sea): palynological evidence. Proceedings of the Ocean Drilling Program, Scientific Results 161: 457–468.

Nielsen, K.A., Clemmensen, L.B. and Fornós, J.J. (2004) Middle Pleistocene magnetostratigraphy and susceptibility stratigraphy; data from a carbonate Aeolian system, Mallorca, Western Mediterranean. Quaternary Science Reviews 23: 1733–1756.

Okuda, M., Yasuda, Y. and Setoguchi, T. (2001) Middle to late Pleistocene vegetation history and climatic changes at Lake Kopais, southeast Greece. Boreas 30: 73–82.

Palmer, M., Pons, G.X., Cambefort, I. and Alcover, J.A. (1999) Historical processes and environmental factors as determinants of inter-island differences in endemic faunas: the case of the Balearic Islands. Journal of Biogeography 26: 813–823.

Palombo, M.R. (2003) Elephas? Mammuthus? Loxodonta? The question of the true ancestor of the smallest dwarfed elephant of Sicily. In J.W.F. Reumer, J. De Vos and D. Mol (eds.) Advances in Mammoth Research. Deinsea 9, 273–291.

Petit, R.J. et al. (2002) Identification of refugia and post-glacial colonisation routes of European white oaks based on chloroplast DNA and fossil pollen evidence. Forest Ecology and Management 156: 49–74.

Petit, R.J. et al. (2003) Glacial refugia: hotspots but not melting pots of genetic diversity. Science 300: 1563–1565.
Poulakakis, N., Mylonas, M., Lymberakis, P. and Fassoulas, C. (2002) Origin and taxonomy of the fossil elephants of the island of Crete (Greece): problems and perspectives. Palaeogeography, Palaeoclimatology, Palaeoecology 186: 163–183.
Ray, N. and Adams, J.M. (2001) A GIS-based vegetation map of the world at the last glacial maximum (25,000–15,000 BP). Internet Archaeology 11 (http://intarch.ac.uk/).
Reille, M. and de Beaulieu, J.-L. (1995) Long Pleistocene pollen records from the Praclaux Crater, south-central France. Quaternary Research 44: 205–215.
Reille, M., Andrieu, V., de Beaulieu, J.-L., Guenet, P.,Goeury, C. (1988) A long pollen record from Lac du Bouchet, Massif central, France for the period 325 to 100 ka (OIS 9c to OIS 5e). Quaternary Science Reviews 17: 1107–1123.
Reille, M., Gamisans, M.J., de Beaulieu, J.J.-L, and Andrieu, V. (1997) The late-glacial at Lac de Creno (Corsica, France): a key site in the Western Mediterranean Basin. New Phytologist 153, 547–559.
Reille, M., Gamisans, V., Andrieu-Ponel, V. and de Beaulieu, J.-L. (1999) The Holocene at Lac de Creno, Corsica, France: a key site for the whole island. New Phytologist 141: 291–307.
Rose, J., Meng, X. and Watson, C. (1999) Palaeoclimate and palaeoenvironmental responses in the Western Mediterranean over the last 140 ka: evidence from Mallorca, Spain. Journal of the Geological Society 156: 435–448.
Rossignol-Strick, M. (1999) The Holocene climatic optimum and pollen records of sapropel 1 in the Eastern Mediterranean, 9000–6000 BP. Quaternary Science Reviews 18: 515–530.
Sadori, L. and Narcisi, B. (2001) The postglacial record of environmental history from Lago di Pergusa, Sicily. The Holocene 11: 655–670.
Sbaffi, L., Wezel, F.C., Curzi, G. and Zoppi, U. (2004) Millennial- to centennial-scale palaeoclimate variations during Termination I and the Holocene in the central Mediterranean Sea. Global and Planetary Change 40: 201–217.
Shackleton, N.J. et al. (1984) Oxygen isotope calibration of the onset of ice-rafting and history of glaciation in the North Atlantic region. Nature, London, 307: 620–623.
Spezzaferri, S., Cita, M.B. and McKenzie, J.A. (1998) The Miocene/Pliocene boundary in the Eastern Mediterranean: results from sites 967 and 969. Proceedings of the Ocean Drilling Programme Scientific Results 160: 9–28.
Sprovieri, R., Di Stefano, E., Incarbona, A., Gargano, M.E. (2003) A high-resolution record of the last deglaciation in the Sicily Channel based on foraminifera and calcareous nannofossil quantitative distribution. Palaeogeography, Palaeoclimatology, Palaeoecology 202: 119–142.
Suc, J.-P. (1984) Origin and evolution of the Mediterranean vegetation and climate in Europe. Nature, London, 307: 429–432.
Suc, J.P., Drivaliari, A., Bessais, E., Guiot, J., Bertini, A., Leroy, S., Cheddadi, R., Ferrier, J. and Duzer, D. (1994) Mediterranean Pliocene vegetation and climate: how to quantify the climate parameters? United States Geological Survey (USGS) Open-File Report 94–23.
Sykes, B. (2001) The Seven Daughters of Eve. Bantam Press: London.
Tzedakis, P.C. (1993) Long-term tree populations in northwest Greece through multiple quaternary climatic cycles. Nature 364: 437–440.
Tzedakis, P.C. (1999) The last climatic cycle at Kopais, central Greece. Journal of the Geological Society of London 156: 425–434.
Tzedakis, P.C., Andrieu, V., de Beaulieu, J.-L., Crowhurst, S., Follieri, M., Hooghiemstra, H., Magri, D., Reille, M., Sadori, L., Shackleton, N.J. and Wijmstra, T.A. (1997) Comparison of terrestrial and marine records of changing climate of the last 500,000 years. Earth and Planetary Science Letters 150: 171–176.
Tzedakis, P.C., Andrieu, V., de Beaulieu, J.-L., Crowhurst, S., Follieri, M., Hooghiemstra, H., Magri, D., Reille, M., Sadori, L., Shackleton, N.J. and Wijmstra, T.A. (2001) Establishing a terrestrial chronological framework as a basis for biostratigraphical comparisons. Quaternary Science Reviews 20: 1583–1592.

Tzedakis, P.C., Frogley, M.R. and Heaton, T.H.E. (2003) Last interglacial conditions in southern Europe: evidence from Ioannina, northwest Greece. Global and Planetary Change 36: 157–170.

Tzedakis, P.C., McManus, J.F., Hooghiemstra, H., Oppo, D.W. and Wijmstra, T.A. (2003) Comparison of changes in vegetation in northeast Greece with records of climate variability on orbital and suborbital frequencies over the last 450,000 years. Earth and Planetary Science Letters 212: 197–212.

Van Couvering, J.A. (ed.) (2004) The Pleistocene Boundary and the Beginning of the Quaternary. Cambridge University Press: Cambridge.

Vesica, P.L., Tuccimei, P., Turi, B., Fornos, J.J., Gines, A. and Gines, J. (2000) Late Pleistocene paleoclimates and sea-level change in the Mediterranean as inferred from stable isotope and U-series studies of overgrowths on speleothems, Mallorca, Spain.

Warny, S.A., Bart, P.J. and Suc, J.-P. (2003) Timing and progression of climatic, tectonic and glacioeustatic influences on the Messinian Salinity Crisis. Palaeogeography, Palaeoclimatology, Palaeoecology 202: 59–66.

Yll, E.-I., Perez-Obiol, R., Pantaleon-Cano, J. and Roure, J.M. (1997) Palynological evidence for climatic change and human activity during the Holocene on Minorca (Balearic Islands). Quaternary Research 48: 339–347.

Chapter 3
Holocene History of Mediterranean Island Landscapes

O. Rackham

Tomba dei Giganti, Sardinia (Photo: I. Vogiatzakis)

During glacial cycles the level of the Mediterranean, like other seas, fell by 120–150 m: enough to join Sicily to Italy, Corsica to Sardinia, and Mallorca to Minorca. Most of the other islands are surrounded by deep sea and would not be much affected unless by tectonic movements at the same time. In the early Holocene absolute sea level rose to approximately what it is now, creating jagged capes and drowned valleys. These have gradually adapted to the new sea level, as rivers have brought down sediment and filled in bays, forming deltas and sandy beaches. On the mainland this continued into historic times, choking ancient harbours and creating agricultural land. On islands this has not happened to the same extent, owing to the lack of big rivers and of badlands to act

Corpus Christi College, University of Cambridge, UK

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as abundant sources of sediment. Islands still have jagged promontories. Some have lagoons. Sardinia has the finest lagoon coasts in southern Europe; the presence of the algal concretions called stromatolites indicates that there were similar lagoons in previous interglacials.

3.1 The Question of Insularization

How do islands differ from the mainland? They may have different environments, different plants, different animals, or a different human history (especially if they had no Palæolithic people).

Low islands such as Santoríni tend to be drier than the mainland, though their rainfall may be supplemented by fog. Islands with mountains higher than 600 m intercept rainfall, giving rain-excesses on the north-west side of the mountains and rain-shadows on the south-east, as in Crete. Islands seldom have rivers that run all the year round, unless fed by karst limestone springs.

Island soils, especially in Crete, are often supplemented by dust blown from the Sahara or other deserts. Many islands are subject to deluges, when half a year's rain or more falls in a single event (as in Corsica on 31 October 1993), which shift vast quantities of sediment and change the landscape overnight.

Island floras are not a mere continuation of the mainland. In Crete two common trees, cypress and pine are Asian species which get no further into Europe. Several African species reach the offshore islets of Crete but get no further into Europe.

Each of the big islands has *endemic* plants found nowhere else. Some of these are common plants. Hillsides in Mallorca in spring are ablaze with the blossom of *Genista lucida;* those of middle Crete are crimson with *Ebenus cretica*, each peculiar to its island. Other endemics may be confined to one gorge or mountain range. Endemics tend to grow on high mountains, cliffs and jagged peninsulas; they avoid forests, coasts and wetlands. Crete has some 200 endemic species and subspecies, nearly one-eighth of the total flora. Comparative endemics statistics are unsatisfactory because authorities on different islands have different standards of what to count as a species. Island endemics, except for those that grow on cliffs, tend to be well defended against browsing animals.

Islands share in the general categories of Mediterranean vegetation (Fig. 3.1):

1. *Forest* of tall trees so close together that there is no room for light-demanding plants between them
2. *Savanna* of big trees widely spaced in phrygana or steppe
3. *Maquis* (*macchia*) of trees – usually evergreen – reduced to the stature of shrubs (Mediterranean trees and shrubs are usually the same species.)
4. *Phrygana* composed of *undershrubs*, woody plants, usually shallow-rooted and short-lived, that cannot grow into trees: for example, species of *Cistus*
5. *Steppe* composed of grasses, bulbous and other herbaceous plants

Fig. 3.1a Categories of Mediterranean vegetation (a) Forest of evergreen oak (*Quercus ilex*). Puig Mayor, Mallorca, November 1994 (Photo courtesy of O. Rackham) (*See Colour Plates*)

Fig. 3.1b Savanna of *Quercus ilex* trees, whose spreading shape proves that they are not the remains of a forest. Burgos, Sardinia, July 1995 (Photo courtesy of O. Rackham) (*See Colour Plates*)

Each of these occurs on most of the big islands. Forest of tall straight trees is local, and mostly either in high-rainfall areas or on abandoned farmland. Savanna is especially characteristic of Sardinia; maquis of lowland Corsica; phrygana of Kythera. A common ecosystem is a mosaic of patches of maquis, phrygana and steppe, related to soil-pockets and fissures in the underlying bedrock.

Islands in the Pleistocene had peculiar animals, often small versions of large herbivores, such as the calf-sized elephant and mountain-climbing pygmy hippopotamus of Crete (Chapter 2), but no effective carnivore. Unbalanced faunas will have

Fig. 3.1c Maquis of dwarfed prickly oak (*Quercus coccifera*). Mount Yùktas, Crete, May 1988 (Photo courtesy of O. Rackham) (*See Colour Plates*)

Fig. 3.1d Phrygana of many species of undershrub. Kapsáli, Kythera, May 2001 (*See Colour Plates*)

created a profound ecological difference between islands and the mainland. On the islands the numbers of herbivores will have been limited by the food supply. What would now be called excessive browsing will have been the normal state of large and middle-sized islands for long periods. Islands would therefore have tended towards savanna or maquis rather than forest.

Fig. 3.1e Steppe of many species of herbaceous plant, stimulated to grow by the burning of the associated phrygana. Kalokairinés, Kythera, May 2001 (Photo courtesy of O. Rackham) (*See Colour Plates*)

Writers from Dante onwards have assumed that forest is the normal vegetation of Mediterranean lands. ‘Shrublands’ and savanna are supposed to be successive stages in the ‘degradation’ of forest, on the basis that no browsing is the ‘normal’ state. This is unlikely on the mainland and impossible on the islands, where sheep and goats are successors to Pleistocene elephants and deer (Chapter 2). Maquis, phrygana, steppe and savanna are not a modern phenomenon but are likely to have been present throughout the Holocene and even before.

Wild vegetation in the Holocene has encountered browsing, woodcutting, burning and drought. Trees and shrubs respond in different ways. Woodcutting kills pines, but arbutus thrives on it; cypress is killed by fire, but arbutus thrives on fire; goats browse arbutus, dislike pine, and will not eat cypress if they can get anything better (Chapter 11).

Whole ecosystems are adapted to fire. Many plants, such as pines, laurel, arbutus, and *Cistus* are fire-promoting; many herbaceous plants are visible only in areas burnt one or two years ago. The prehistory of fire is little known: possibly the ‘natural’ state was huge, hot conflagrations on rare occasions when lightning ignited decades of accumulated fuel, which would have changed into frequent, smaller, less hot fires after people arrived and developed techniques of occupational burning.

Most Mediterranean trees survive woodcutting. They *coppice*: they sprout from the stump and produce stems which yield successive crops of wood. Huge coppice stools, several centuries old, are a feature of many island landscapes (Fig. 3.2). Damage to the young growth by browsing animals can be prevented

Fig. 3.2a Ancient coppice stool of *Quercus coccifera*, which has been felled and has sprouted many times. Lákkoi, west Crete, July 2005 (Photo courtesy of O. Rackham) (*See Colour Plates*)

Fig. 3.2b Ancient pollard deciduous oaks (*Quercus pubescens*). Fonni, Barbagia Ollolai, Sardinia, April 1992 (Photo courtesy of O. Rackham) (*See Colour Plates*)

Fig. 3.3 Lémnos, most arid of the middle-sized Greek islands. September 2004 (Photo courtesy of O. Rackham) (*See Colour Plates*)

by cutting the trees as *pollards*, 3–5 m above ground. Prickly oak, *Quercus coccifera*, commonest of Aegean trees, is highly resilient to browsing, burning and woodcutting.

The strongest determinant of vegetation is usually moisture: a combination of rainfall, water retention, and root penetration. Savanna and maquis occur where there is enough moisture for trees but not enough for forest. This is illustrated by the desert-like Greek island of Lémnos, with low rainfall and intensely hard, impenetrable volcanic rocks: it has hardly a wild tree or shrub but great extents of phrygana and steppe (Fig. 3.3). Across 55 km of sea to the north-west is the high, rainy peninsula of Athos, so very forested that non-forest plants and animals are quite restricted. In the other direction is Lésbos, on softer, more weathered volcanic rocks, a higher island with vegetation ranging from steppe to forest and great areas of savanna.

3.2 The Pollen Record

Most of what is known about the Quaternary ecology of the Mediterranean is derived from fossil pollen, but also animal remains and charcoal (Vernet 1997). There are few suitable sites on the islands; other difficulties include the under-representation of the many insect-pollinated undershrubs and herbaceous plants in the pollen record, and the impossibility of distinguishing tall trees from the same species which occur as shrubs.

Glacial periods were expressed in the Mediterranean as dry rather than cold periods (Corsica and, on occasion, Crete had glaciers). Trees survived in favoured spots. In the early Holocene, from about 11,000 years ago, the climate became more favourable and trees returned to most of the Mediterranean. Usually the trees included more deciduous than evergreen species, contrary to the present state. They also included ‘north European’ trees like birch, alder, and lime, which extended further south than now. The trees are conventionally interpreted as forest, which they may have been in wetter and marginal parts of the region. However the presence of pollen of herbaceous plants which do not flower in shade, such as asphodel, means that some of the tree-land was savanna (cf. Grove and Rackham 2001) or maquis rather than forest.

In these *wildwood* times, as now, Mediterranean landscapes and vegetation were not uniform. In the south of Spain evergreen oaks predominated and there were not many northern trees. In the south of Greece there was savanna of pine and oak.

In later prehistory vegetation changed to something like the present. Trees became less prominent; northern trees retreated; deciduous oaks gave way to evergreen; undershrubs emerged as major constituents of vegetation. This is partly the effect of the expanding impact of humanity: deciduous oaks probably declined because they grew on soils worth cultivating. However, much of the change can be attributed to a climatic shift, a process of *Aridization*, known from other evidence to have occurred in the middle Holocene (5000–2000 BC) (Grove and Rackham 2001; Hempel 1990). It occurred in several phases, with ups and downs of climate not unlike the Little Ice Age of historic times. It had more effect in Spain and Greece than the middle Mediterranean. Sardinia with its alders gives an impression of a pre-Aridization landscape.

3.2.1 Island Pollen Analysis

3.2.1.1 Corsica

Corsica has many pollen deposits at different altitudes (Reille 1992; Reille et al. 1997, 1999). During the late-glacial steppe dominated; in the early Holocene it gave way to trees and shrubs, especially tree-heather mixed with *Arbutus*. This is the origin of Corsica’s characteristic maquis. Above 1,500 m Corsican pine and fir (*Abies*) were dominant. Except along the coast, non-forest indicators are weak: native herbivores were either scarce due to the forest being too dense for them or had already become extinct. Northern trees are well represented; alder, yew and lime were abundant at low altitudes. Aridization was not severe: Corsica remains mostly forested, and all the northern trees except hornbeam are still represented.

3.2.1.2 Balearics

Minorcan pollen diagrams tell a peculiar and unexpected story, and are difficult to interpret in terms of extant plant communities. In the middle Holocene the vegetation was dominated by box (presumably the endemic *Buxus balearica*) and juniper, with some oaks (evergreen and deciduous) and northern trees (hazel, alder, elm); wind-pollinated undershrubs (*Thymelaea, Ephedra*) and insect-pollinated herbs are well represented. The likely picture is of a mosaic of box and juniper thickets with patches or scatters of trees, and patches of phrygana and steppe (Yll et al. 1997).

3.2.1.3 Sicily

A pollen deposit from the small lake of Pergusa in the dry centre of Sicily covers most of the Holocene. The overwhelmingly predominant tree was deciduous oak, rising to a peak around 6300 BC; there were also evergreen trees and a few northern trees such as hazel and beech. The picture is of fairly densely treed savanna with moderate amounts of Chenopodiaceae, Compositae and other steppe plants (Sadori and Narcisi 2001).

3.2.1.4 Mljet

This is a smallish, low, but relatively rainy island off the Dalmatian coast. A peat deposit begun to accumulate c.8000 BC. At this stage deciduous oak was dominant, with hazel and a little elm. The record indicates forest, with very little steppe and no undershrubs. The frequency of elm, the most palatable of trees, probably means a lack of herbivores. Around 6300 BC there was a sudden change to juniper and *Phillyrea* with small amounts of evergreen oak. This was probably forest, but a forest with no close parallels today. This change might have been brought about by Aridization or by Neolithic people (Beug 1961, 1967).

3.2.1.5 Crete

Seven pollen diagrams (Fig. 3.4) span the period from c.8000 BC (just before known human presence) almost until now, but not continuously nor all in one place (Bottema 1980; Moody et al. 1996; Atherden and Hall 1999; Atherden 2000; Bottema and Sarpaki 2003). Although it is difficult to generalize, pollen analysis from Crete disproves a number of well-worn beliefs:

1. The island was never continuously forested; even before the Aridization it had savanna and at least local phrygana.
2. Cypress never covered the whole island: it has seldom been commoner than it is now.
3. Crete has not progressively lost its forests: trees have decreased at some times and increased at others.

The two diagrams that begin in the pre-Neolithic show sparsely tree'd landscapes. At Dhélphinos the principal tree was deciduous oak, with a phrygana component (e.g. *Phlomis*) as well as steppe, indicating oak savanna, as is still characteristic of this part of Crete. At Ayia Galíni the sediments include abundant deciduous and

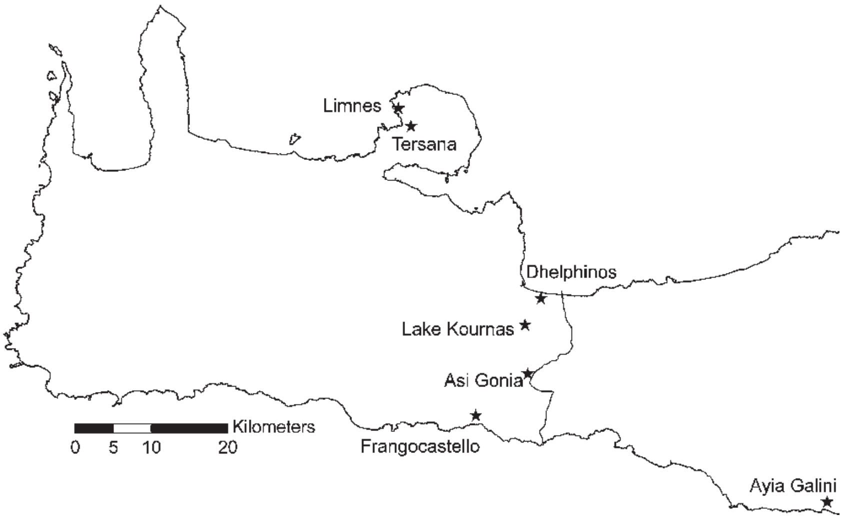

Fig. 3.4 Pollen deposits on Crete

evergreen oak pollen, and northern trees such as alder, lime, and elm. Non-trees were mainly insect-pollinated steppe plants, including abundant asphodel, an 'indicator of over-grazing'. The date is too early for domestic animals: could native mammals still have persisted? Here the wildwood landscape was utterly different from the present: this part of Crete is now too arid even for evergreen oak.

3.2.2 Conclusions

The pollen record allows little generalization. Aridization occurred on most of the islands that have pollen, but in other respects each island reacted individually. Some of the present distinctive landscapes of parts of Crete have roots far back in the Holocene. But the Mljet story is difficult to relate to present vegetation, and the possibility that Mallorca was covered with thickets of endemic box, browsed by flocks of the box-eating, goat-sized endemic beast *Myotragus balearicus* (Bover and Alcover 2003) is difficult to contemplate.

It is often assumed that islands, while losing their native mammals, have kept their native plants. *Buxus balearica*, however, is extinct on Minorca, surviving only on Mallorca. Cretan pollen records provide further exceptions. Some pre-Aridization trees such as lime and alder are now apparently extinct on the island; ash and elm are now confined to a few favoured spots. *Osmunda*, a northern fern found in Corsican and Cretan deposits, is now only in a few north-facing, continuously wet sites. The herbs *Aquilegia* and *Rhinanthus* are now extinct in Crete; *Thalictrum* has been re-found in the

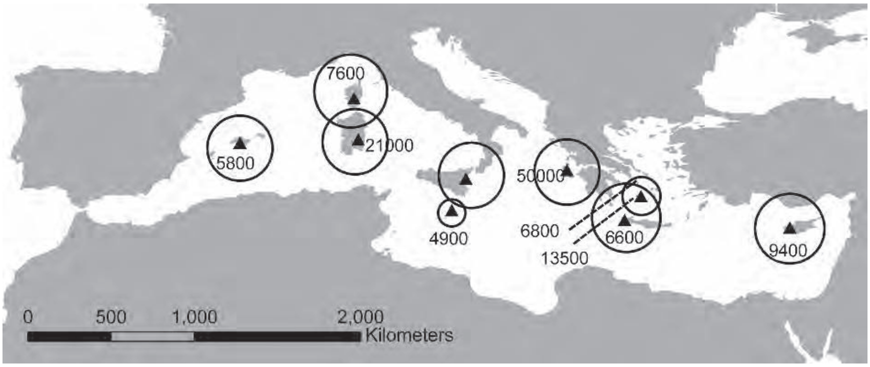

Fig. 3.5 Date (in corrected radiocarbon years BC) of earliest known human presence on various islands (Cephalonia 50,000; Sardinia 21,000; Melos 13,500; Cyprus 9,400; Corsica 7,600; Kythnos 6,800; Crete 6,600; Balearics 5,800; Malta 4,900)

high mountains. Despite the incomplete nature of the pollen record, there have been significant losses of native plants either to browsing, cultivation, or climate change.

3.3 Human Inhabitants

3.3.1 Peopling the Islands

Palaeolithic people spread throughout the Mediterranean coasts during the Pleistocene; they crossed 3 km of sea into Sicily. They would soon have 'discovered' most of the islands – all the big ones except Sardinia can be seen from the mainland (Fig. 3.5) – but had no means of reaching them, even when sea level was lower. On present evidence, people did not settle the islands immediately they had invented boats, but sporadically over tens of thousands of years (Fig. 3.5).

The earliest known island archaeological site is from the middle Palaeolithic (c.50,000 years ago) on Cephalonia, then 20 km across the sea from west Greece; but no further human settlement is known until the middle Pleistocene. The next definite evidence is from Sardinia, the only big island that *cannot* be seen from the mainland, about 23,000 years ago.

The distinctive obsidian produced by the Greek island volcano of Mélos was used on the mainland to make stone tools, beginning around 13,500 BC. To reach Mélos is a 100 km voyage across the open sea, or a series of 20 km voyages between intermediate islands. If Upper Palaeolithic people could fetch cargoes of obsidian from Mélos, they could have gone on to Crete, whose towering mountains are plainly visible from the Peloponnese. Crete has plenty of caves in which Palaeolithic and Mesolithic material might be expected. They have been abundantly investigated by archaeologists and by zoologists studying Pleistocene mammals but on present evidence the earliest human presence in Crete is Neolithic, about 6600 BC.

Other islands were apparently settled in the late Mesolithic or Neolithic: as discussed in Chapter 1 (Table 1.4). However Mélos and Crete, and perhaps Corsica and Sardinia, raise the suspicion that people explored islands, and perhaps altered their ecology, long before they created an archaeological record.

3.3.2 People and Ecology

Palaeolithic and Mesolithic people may have had a profound impact on mainland ecology. Although few in numbers and not tilling the soil, they apparently exterminated elephants and other great herbivores. By manipulating the frequency of fire they may have encouraged fire-dependent vegetation. They would thus have altered the balance between forest, savanna and steppe in ways that are still not clear.

From the Neolithic onwards, people had further effects, some of them cumulative. They dug up natural vegetation to make farmland, and built terraces. They introduced domestic animals. They altered the remaining vegetation by browsing and woodcutting. They introduced cultivated plants and weeds. Some of the plants that they introduced, deliberately or accidentally, invaded native vegetation. They introduced new plant diseases.

The effect of human settlement on oceanic islands like St. Helena is well documented. The sudden irruption of Humans and Humans' henchmen – Dog, Pig, Rat, Goat – into unstable volcanic islands that had never known any mammal except bats and seals was disastrous to the fauna, vegetation, and even to the very fabric of the islands. This could result even from visits by passing ships that left little archaeological trace.

Mediterranean Islands, except perhaps the smallest, were not like this. Their plants had had ample experience of herbivorous mammals and opportunities to adapt to resist browsing. Their animals had had no experience of carnivores, and had lost their adaptations to resist being eaten. For the first hunters, and especially the first dogs, the islands should have been a paradise of edible animals that would not even run away. One might imagine that the first impact of humanity, either as settlers or as explorers, would have been the extermination of native herbivores, resulting in an increase of forest, followed by a gradual return of browsing as sheep and goats came to replace elephants and deer.

As yet this cannot be demonstrated: there are not enough pollen records spanning the relevant millennia. In Crete the last positive evidence of native mammals is around 24,000 years ago, well before evidence of human settlement. Although future research may narrow this gap, if people exterminated the deer it would have been as visitors rather than settlers. On Kythnos and Tílos islands in Greece pygmy elephants survived well into the Holocene and could well have been exterminated by Mesolithic people. On Mallorca, Sardinia, and Cyprus, some native mammals survived the coming of people and coexisted with settlers: the endemic rabbit of Mallorca and the chamois of Sardinia probably lasted into the Bronze Age.

Neolithic people introduced domestic animals, some of which escaped and began to repeat the evolutionary divergence of mammals stranded on islands. The *agrími*, for which Crete has been famous since the Bronze Age, is a Neolithic feral goat. The *mouflon* of Corsica and Sardinia, and probably its cousins in Cyprus, is a Neolithic feral sheep. However, the wild pigs of Corsica, Sardinia and Cyprus are probably introduced Eurasian wild swine, and the former fallow deer of Crete were introduced and not derived from native deer.

3.3.3 The Later Pollen Record

How can the effects of Aridization be separated from those of Neolithic and Bronze Age people? It can no longer be assumed that changes in vegetation before the Neolithic must be due to climate, and after to human activity. Field evidence and the pollen record must be examined for specific patterns of extinction and survival in relation to climate, or for the known effects on specific plants of specific kinds of human activity. Lime and alder survive in southern Greece on north-facing cliffs and by cold perennial rivers, which indicates that Aridization is responsible for much, if not all, of their decline elsewhere (Pigott and Pigott 1993). Deciduous oaks, however, probably declined because agriculture competed with them; they are now returning on abandoned agricultural land.

In the Mediterranean the ‘Neolithic revolution’ (i.e. the onset of permanent agriculture) was less drastic than in northern Europe and is more subdued in the pollen record. It was less a matter of destroying forest and replacing it by farmland as of converting savanna (grassland or phrygana with scattered trees) into well-tree’d farmland.

3.3.3.1 Corsica

The later pollen record indicates a complex pattern of change and stability in different parts of the island, of advances and retreats of non-forest vegetation and of different trees within the forests. Reille (1992) ascribes these to Neolithic human activities, but without giving enough ecological detail to make all his explanations persuasive. For example, he claims that a decline of tree-heather and alder in favour of yew and Corsican pine, around 5600 BC, was due to artificial burning: yet of these four trees heather and pine are fire-adapted, and alder and probably yew are fire-resistant. The natural ecology of even common trees is not fully known: such changes should remain unexplained until better modern parallels are found.

After 4000 BC there came a general change. At low altitudes deciduous oaks declined, and a more arid type of maquis developed, with lentisk and *Phillyrea*. In the tree-heather zone evergreen oak, rare or absent in the early Holocene, became co-dominant. This mysterious change is ascribed by Reille to Neolithic agriculture letting the oak colonize the maquis. However this is implausible as elsewhere in the Mediterranean *Quercus ilex* is held back by browsing and burning except in high-rainfall areas.

From Roman times onwards agricultural weeds and phrygana (e.g. *Cistus*) come to be abundant in some pollen diagrams; but the landscape was evidently complex, and trees predominate at many sites.

3.3.3.2 Minorca

At around 5500 BC there was a dramatic change. Within a few centuries the box-juniper mosaic was entirely replaced by olive, with more abundant phrygana and steppe. Northern trees, however, continued. Olive (as yet apparently wild olive) must have been a substantial tree, not a maquis bush, in order to produce large quantities of pollen. The picture is of savanna of scattered trees in a mosaic of steppe and phrygana.

The sudden and complete change, in which every single box-tree disappeared from Minorca, is difficult to explain. The investigators attribute it partly to Aridization: it would be equivalent to a change in climate from sea level to 900 m, the altitude at which *Buxus balearica* is now abundant on the higher island of Mallorca. Two other changes were going on: expansion of Neolithic human activity, and extinction of *Myotragus*. However, *B. balearica* withstands human activities very well on Mallorca: it is hard to see how either climate change or the replacement of *Myotragus* by sheep and goats would completely exterminate box from Minorca.

3.3.3.3 Sicily

The Neolithic was marked by the beginning of an increase in olive and a gradual decline of deciduous oak, but with no sudden change. Elm became quite abundant in the Bronze Age: there is no sign (here or in any other island pollen core) of the sudden Elm Decline at 3800 BC which is so characteristic of northern Europe.

As might be expected for an island so close to the mainland, the story in Sicily is not very different from Italy. As in Italy, Aridization was subdued compared to Spain or Greece. Although the lake still exists, the top of the core still indicates oak-olive savanna, which contrasts with the present arid, treeless surroundings of what has become a salt lake.

3.3.3.4 Mljet

In common with Corsica is the late appearance of evergreen oak and lowland pine. The former, already present in the juniper period, rapidly became dominant around

5500 BC. *Phillyrea* declines, and lentisk, indicator of the drier type of maquis, became significant in the last two millennia BC, with lowland pine later still. This possibly indicates Aridization. Trees continued as the predominant vegetation, without much phrygana or steppe.

3.3.3.5 Crete

Pollen records tell the stories of four or five different Cretan landscapes. The three that cover the Neolithic period show fluctuations in trees, including at one site a short period of near-continuous forest in the mid to late Neolithic. Phrygana, already abundant in the Akrotíri Peninsula, tended to increase. Evergreen oak (in Crete mainly *Quercus coccifera*) increased at the expense of deciduous oak. There was a slow and interrupted decline in north European trees.

The earliest unambiguous evidence of human activity in the pollen record is the appearance of large amounts of olive in the late Neolithic (4400–3500 BC). Walnut and carob, anciently introduced cultivated trees, appear in the Roman period.

For the historic period there is a detailed pollen deposit at Así Goniá in a less arid region with water-retaining soils on phyllite, more like Corsica than other parts of Crete. In the late Roman period it had dense savanna of evergreen oak, plane, arbutus, and tree-heather: such still exists a few kilometres away, though the site itself is now less vegetated. In the late first millennium AD trees declined and phrygana became abundant. Fluctuations in the second millennium may be related to the ups and downs of the economy of Crete or to the phases of the Little Ice Age between c.1320 and 1820. Phrygana changed from predominantly *Cistaceæ* to *Sarcopoterium* and *Labiatæ*. In the last 100 years oak, especially deciduous, has recovered as cultivation has declined.

3.3.4 Island Civilizations

From time to time islands have peculiar, independent human cultures. The Minoan of Crete flourishing from 2900 to 1150 BC, had monumental buildings and a high density of population. Sardinia had an Iron Age culture, in the last millennium BC, still dramatically visible in the form of several thousand *nuraghes*, massive dry-stone round towers that are equivalent to fortified manor-houses, sometimes in what is now deep forest. Similar but earlier megalithic cultures arose independently in the Balearics and Malta.

Some island cultures were the result of colonization. Cyprus was brought into the Greek world in the Iron Age. The Phoenicians in Sardinia set up their civilization alongside the native Iron Age. Classical Greek colonies made Sicily part of the Greek world, with Classical monuments hardly exceeded by those of Greece itself.

Some very small islands have had periods of dense population well beyond their own resources. In the Aegean, tiny arid Délos has one of the greatest concentrations of Classical Greek archaeology: it was a sacred city and a place of pilgrimage. For nearly 500 years, Malta, although agricultural, has lived mainly by seafaring from its excellent karst harbours, whether trading, or corsairing (under the Knights Hospitallers), or as a naval base. Other places have no written record and are not so easily explained. Why is Gavdhos (30 km^2), the southernmost outpost of Europe, so thickly strewn with late Roman sherds? Why was Kouphonísi (4.2 km^2), off the south-east corner of Crete, such an important Hellenistic and Roman site? What could such an arid speck of land, now mainly sand-dunes, have done for a living?

3.3.4.1 Settlement Patterns

Minoan Crete had a well-defined hierarchy of settlements: hamlets, villages, small towns and large towns. Towards the end of the Bronze Age many hamlets and small towns were deserted, producing a landscape of villages with the occasional large town. In the Iron Age the people moved into larger towns on hilltops, which later developed into the 'hundred cities' of Classical Crete (Rackham and Moody 1996).

Comparable changes were typical of Europe as well as the Mediterranean Islands (Fig. 3.6). A common pattern was for small settlements, hamlets or even single farms, to predominate in the early middle ages. Typically around the 12th century, these would be replaced by villages or small towns, often round a castle (whence the Italian term *incastellamento*). Villages became institutionalized as the predominant settlement type, especially as the parish church, shops and inns emerged as the cement of social life.

Sardinia displays *incastellamento* in an extreme form, with towns and big villages, some 300 in the island, about 20 km apart in an otherwise empty countryside. There are occasional remains of a previous hamlet pattern. In the Iron Age it was quite different: there were more than 4,500 hamlets, usually clustered round *nuraghe* towers. Corsica is still an island of hamlets, but without *nuraghes*.

Sicily is a land of hill-towns rather like Sardinia, except for the hamlets round Mt. Etna. Malta is highly nucleated, as are most Greek islands and Cyprus. The villages of Mallorca contrast with the hamlets of Minorca; off Dalmatia the hamlets of Hvar contrast with the villages of Mljet.

Crete is more complex. After the Roman period the 'cities' mutated into a multitude of hamlets. In many parts of the island these later reorganized themselves into villages, but nearly half of Crete remains a land of hamlets, especially in the west. This is almost unique in Greece, except on some of the other islands. Kythera has at least 60 hamlets and three towns (and 101 parish churches) on 280 km^2 of land for a population that has never exceeded 14,000.

3.3.4.2 The Perils of the Coast

The present concentration of population on coasts is exceptional in history. Coasts have been dangerous to live on because of the risk of pirates seeking treasure, ransoms, and slaves. As late as 1893, *Baedeker's Handbook* shows remarkably few

Fig. 3.6a Landscape of hamlets, in east Crete north of Ayios Nikolaos. British Military Map (1943) ruled into 1km squares

Fig. 3.6b Landscape of villages, in east Crete south-east of Ayios Nikolaos

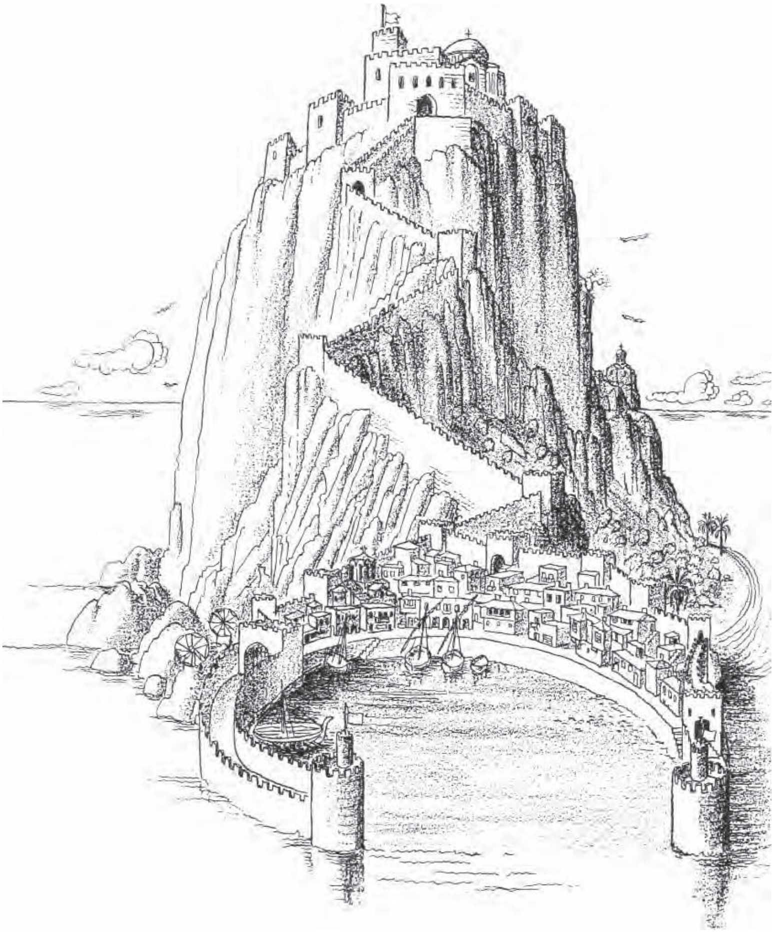

Fig. 3.7 Osbert Lancaster's vision of a small island in the middle ages. The Saracen's Head (used with permission by Lady Lancaster)

settlements, other than ports, on the coast of Sicily: people had lived in mountain villages and ventured trembling down to the coast, if at all, to till their fields when pirates were not about. Any island less than 10 km wide was likely to be deserted altogether when piracy was rife (Fig. 3.7).

Piracy is thought to be the reason for the contrast between the populous coasts in the Aegean Bronze Age and their desertion in the Iron Age. The Romans made a point of executing pirates, and coastal settlement flourished again. With the waning of Byzantine sea-power, especially after the Fourth Crusade in 1204, coasts and small islands again became untenable. As Arabs, Turks and Crusaders took over the Mediterranean coast, piracy became institutionalized. With Christian and Muslim powers forever locked in

Fig. 3.8 Small part of the Genoese—Turkish castle of Mitylene on Lésbos. September 2004 (Photo courtesy of O. Rackham)

holy war, each side would plunder the other's ships, and would venture forays on land. By 1500, the entire Cretan coast, except for fortified towns and monasteries, and nearly the whole east end of the island had been abandoned.

European powers tried to fortify their distant islands against corsairs and the advancing Muslim powers. The Genoese built giant castles on Lésbos (Fig. 3.8) and Chios. Some islands were forward bases and were the scene of famous sieges. Rhodes, headquarters of the Knights Hospitallers, soldier-monks, was fortified on a colossal scale, and in 1521 held out for three months against Süleyman the Magnificent whose army had conquered all Yugoslavia. The Knights went off to a second career as pirate-monks based on Malta, building another super-fortress that saw off attacks by Süleyman and, four centuries later, by Hitler. When the Turks invaded Crete in 1645 they quickly overran most of the island, but the Veneto-Cretans in their fortified city held out for 22 years.

Islands, however well fortified, are difficult to defend because raiders can choose where to land undetected. The great corsair Khair-ed-Din of the Red Beard sacked Réthymnon (Crete) and Kythera in the 1530s under the noses of the garrisons. The kings of Spain, who had mercilessly persecuted their Muslim and ex-Muslim subjects, invited retribution. In the 1590s they had to build armed towers every 5 km or so on the south coast of Spain, and all round the island of Sardinia (Fig. 3.9). The last great raid on Sardinia was in 1815, and the towers were manned until 1867.

Fig. 3.9 Coast-defence tower. Nora, Sardinia, April 1992 (Photo courtesy of O. Rackham)

Fig. 3.10 Terraces, partly in use and partly reverted to savanna. Stypsi, Lésbos, September 2004 (Photo courtesy of O. Rackham)

Fig. 3.11 Archaeology of tourism: decayed spa on the island of Rhodes, dating from the Italian period in the 1930s. Kallithea, March 1990 (Photo courtesy of O. Rackham) (*See Colour Plates*)

3.3.4.3 The Cultural Landscape: Fields and Roads

Planned ancient field systems, like the Roman *centuriation* that still dominates wide areas of north Italy, are uncommon on islands, but there are several in Crete (see Chapter 11). The north European practice of open-field strip-cultivation did not much penetrate the Mediterranean except in Sardinia, where it is still locally visible.

Terraces are far more widespread (Fig. 3.10). They are difficult to date. The earliest datable terraces in Europe are of the Middle Bronze Age (2200–1700 BC) on the islet of Pséira off Crete; they are recognizable because this island was inhabited in only one other period (Clark 2004). Terracing is abundant on Crete, with local exceptions; it reaches into the mountains far above the present limit of cultivation. It occurs on most other Greek islands, Mallorca, much of Corsica and Malta. On Sardinia it is curiously local in the Bosa area and the Barbagia mountains. There is little terracing on Rhodes or Sicily.

Reasons for terracing or not terracing are usually a matter of conjecture rather than hard fact. In Rhodes and parts of Crete lack of terraces may be related to unstable geology in which terraces could provoke landslips. In Sardinia and Sicily insecure land tenure may have discouraged cultivators from investing labour or money in building terraces.

Fields with walls (less often hedges) round them can be of any date. They may be the product of 'land reform' and the privatization of common-lands that was fashionable in the mid-19th century. Many of the uplands are parcelled out into big fields by walls in straight lines, inserted between the pre-existing savanna trees and themselves intersected by the slightly later railways.

Some landscapes are designed for vehicles, others not. Islands such as Sicily and Sardinia have a tradition of carts, cart-roads, and cart-bridges. Most Aegean islands are meant for pack animals. Crete, after the Bronze Age, had no vehicles until the 1880s; but it had a very well-developed network of paved roads, $4^{1}/_{2}$ m wide and provided with steps, showing they were not meant for wheels.

Ancient trees are a feature of cultural, rather than wholly natural, landscapes. Examples are the medieval or earlier chestnuts of Corsica and Crete (and the Hundred-Horse Chestnut, *Castagno di Cento Cavalli*, on Mt. Etna); the Hellenistic and Byzantine olives of Crete; and the savanna deciduous oaks of Barbagia in Sardinia (Fig. 3.2b). Some grow on terraces, thus dating the terrace to older than the tree. Many are pollards, repeatedly cut in various styles to provide successive crops of wood or leaves. Ancient trees, and the savannas that contain them, are important ecologically because they are a habitat for specialized plants and animals, from lichens to hole-nesting birds; this aspect has been neglected in southern Europe.

3.4 Recent Changes

The last 150 years appear to have been a time of particular instability in most matters except climate. Many changes and problems are not common to the islands, but are either shared with the mainland or are peculiar to one island.

For 150 years the population has risen, on most islands as on the mainland. This was partly offset by the suppression of piracy, adding to the usable land area by making the coast safe to live on, and by emigration. Some islands, particularly in the Aegean, founded overseas colonies and still remain in touch with them; tiny Kastellorhizon, remotest of Greek islands, has two Australian colonies.

Islands such as Sardinia, Sicily and Lésbos developed industries in the nineteenth century, and later incurred the problems of industrial decay. The mountains of Sardinia are full of derelict mines, whose waste products contaminate the water supply. Sardinia belongs to one of five countries that produce the world's cork. The bottle-cork industry began there in the 1830s. A distinctive feature of Sardinia (and of no other island except the south tip of Corsica) is groves of cork-oak 60–100 years old, which grow close together in forests instead of the savanna which is the normal habitat of this tree.

At the same time agriculture began to be 'improved' by machinery, imported fertilizers, new crops from America, and by long-distance transport taking produce to distant markets. These came more slowly and unevenly to islands than to the mainland. Agriculture prospered in the lowlands and declined in remote places and on steep, especially terraced, terrain where machinery was of less use. People abandoned the mountains for lowland cities and villages, or moved off the islands altogether.

For centuries tourists had visited islands, especially pilgrims going to sacred islands such as Tínos and Pátmos (see Chapter 5). Mass tourism began when the Italians built hotels and airports in Rhodes in the 1930s (Fig. 3.11). After 1960 it spread to most big and middle-sized islands as it did in the mainland, but unevenly. Corfu has about as much tourism as the whole of Sardinia (but still has a countryside), while in Kythera tourists are almost unknown.

Motor roads have pervaded most islands. There is often a contrast between roads of the 1930s, narrow and well built, and those of the 1970s and later which are of lower standards.

After 1960 came plastic greenhouses and piped irrigation, which encouraged market gardening to feed the tourists. Later came subsidized crops, especially olives. Here, too, there are differences between islands. In Crete much cultivation is done with bulldozers, which (like poor-quality road-making) promotes erosion and destroys the archaeology. Most of the lowlands are full of olives (the result of successive increases of olive trees from the 1700s to the 1980s), most of them now irrigated. In Sardinia there is almost no bulldozing, and olives are still very local; in 1994 large areas of lowland farmland had gone out of cultivation and attracted set-aside payments.

Small islands are usually more depopulated than big ones. Some islets have declined to the point that they no longer support a school, priest, or doctor, but few have been completely abandoned. In most islands horses, mules and donkeys have declined; in some, such as Crete, cattle have become a rarity. The Balearics have almost lost their distinctive pink pigs with black hair. Sheep and goats have often prospered or even increased, but they now have more land to feed on and fewer other livestock with which to share it. Abandoned terraces are a feature of most islands.

Land abandonment results in an increase of forest and other semi-natural vegetation. An extreme example is Gávdhos, the southernmost islet in Europe, and the most exposed to desertification if the Sahara expands northwards. For centuries it was renowned as almost treeless; it is now (unless there has been a fire) about two thirds pine and juniper forest.

Ex-farmland does not revert to the vegetation that it would have had if it had never been cultivated. The new vegetation, such as pine forests and cistus thickets, is usually of fire-promoting species (Fig. 3.12). Most Mediterranean countries report an increase in fires. Although some of this is due to increased efficiency of reporting, part of the increase is real: there is more fuel to burn, and combustible vegetation is less broken up by fields and vineyards which would act as firebreaks. Removing sheep and goats easily turns a browsing-dominated landscape into a fire-dominated landscape. Some islands, such as Thásos and Chios, are becoming locked into a pine-and-fire cycle. Mediterranean foresters make matters worse by planting pines and other highly flammable trees. This happens less on islands, but Kythera (doubtless influenced by its Australian colony) began planting eucalyptuses c.1970, and has been plagued by fires ever since.

Fig. 3.12 Burnt pinewood on agricultural terraces. Cultivation was abandoned, the land became overgrown with pines, and has now burnt, probably for the second time. Soúyia, west Crete, July 1988 (photo: Rackham)

Recent changes tend to turn the diverse landscapes of the historic past into monotonous, non-distinctive ones: the mosaic of fields, terraces, shrublands and habitations becomes either industrial farmland, or shabby coastal development, or wide tracts of phrygana, or uniform forests or burnt forests. This has happened unevenly. Mallorca, despite its huge but localized tourist industry, retains most of its distinctive landscape, and even has some fully operational terraces. Distinctive island landscapes have so far resisted globalization rather better than the mainland.

References

Atherden, M. (2000) Human impact on the vegetation of southern Greece and problems of palynological interpretation: a case study from Crete. In: P. Halstead and C. Frederick (eds.) Landscape and Land Use in Postglacial Greece. Sheffield Academic Press, 62–78.

Atherden, M.A. and Hall, J.A. (1999) Human impact on vegetation in the White Mountains of Crete since AD 500. The Holocene 9: 183–93.

Baedeker, K. (1893) Italy: Handbook for Travellers, 11th edn. Baedeker: Leipsic.

Beug, H.-J. (1961) Beiträge zur postglazialen Floren-und Vegetationsgeschichte in Süddalmatien: der See 'Malo Jezero' auf Mljet. Flora (Jena) 150, 600–631.

Beug, H.-J. (1967) On the forest history of the Dalmatian coast. Review of Palaeobotany and Palynology 2: 271–279.

Bottema, S. and Sarpaki, A. (2003) Environmental change in Crete: a 9000-year record of Holocene vegetation history and the effect of the Santorini eruption. The Holocene 13: 733–749.

Bottema, S. (1980) Palynological investigations on Crete. Review of Palaeobotany and Palynology 31: 193–217.

Bover, P. and Alcover, J.A. (2003) Understanding Late Quaternary extinctions: the case of *Myotragus balearicus* (Bate, 1909). Journal of Biogeography 30: 771–781.

Clark, J.A. (2004) Soils and land use at Pseira. In P.P. Betancourt, C. Davaras and R. Hope Simpson (eds.) Pseira VIII: The Archaeological Survey of Pseira Island Part 1. INSTAP: Philadelphia, PA, 27–54.

Grove, A.T. and Rackham, O. (2001) Nature of Mediterranean Europe. Yale University Press.

Hempel, L. (1990) Forschungen zur Physischen Geographie der Insel Kreta im Quartär Vandenhoeck & Ruprecht, Göttingen.

Moody, J., Rackham, O. and Rapp Jr., G. (1996) Environmental archaeology of prehistoric NW Crete. Journal of Field Archaeology 23: 273–297.

Pigott, C.D. and Pigott, S. (1993) Water as a determinant of the distribution of trees at the boundary of the Mediterranean zone. Journal of Ecology 81: 557–566.

Rackham, O. and Moody, J.A. (1996) The Making of the Cretan Landscape. Manchester University Press: Manchester, UK.

Reille, M. (1992) New pollen-analytical researches in Corsica: the problem of *Quercus ilex* L. and *Erica arborea* L., the origin of *Pinus halepensis* Miller forests. New Phytologist 122: 339–378.

Reille, M., Gamisans, J., Andrieu-Ponel, V. and Beaulieu, J.-L. (de) (1999) The Holocene at Lac de Creno (Corsica, France): a key site for the whole island. New Phytologist 141: 291–307.

Reille, M., Gamisans, J., Beaulieu, J.L. de, Andrieu, V. (1997) The late-glacial at Lac de Creno (Corsica, France): a key-site in the western Mediterranean basin. New Phytologist 135: 547–559.

Sadori, L. and Narcisi, B. (2001) The postglacial record of environmental history from Lago di Pergusa, Sicily. The Holocene 11: 665–670.

Vernet, P. (1997) L'homme et la Forêt Méditerranéenne de la Préhistoire à nos jours Errance, Paris.

Yll, E.-I., Perez-Obiol, R., Pantaleon-Cano, J. and Roure, J.M. (1997) Palynological evidence for climatic change and human activity during the Holocene on Minorca (Balearic Islands). Quaternary Research 48: 339–347.

Chapter 4
Island Biogeography and Landscape Ecology

I.N. Vogiatzakis[1] and G.H. Griffiths[2]

Two Cretan plant endemics a) *Ebenus cretica* b) *Origanum dictamus* and the Cretan ibex *Capra aegagrus* (Photos: Th. Arampatzis)

[1] Centre for Agri-Environmental Research, University of Reading, UK

[2] Department of Geography, University of Reading, UK

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4.1 Introduction

Islands have always been a source of fascination and inspiration for biogeographers. Ecological processes on islands were the focus of early work by Darwin (1859) and Wallace (1892) and later inspired a critical theory in biogeography, the theory of island biogeography (MacArthur and Wilson 1967). True islands have high rates of colonisation and extinction, unusually high proportions of endemic and relict species, and good dispersers and favour the evolution of 'peculiarities': dwarf, giant and flightless forms (Huggett 1998). The majority of comparative studies on island biogeography deal with islands in the Pacific, Indian and Atlantic oceans (Grant 1998; Whittaker 1998; Stuessy and Ono 1998). This can be partly attributed to the pioneer work in the field by Wallace and Darwin but also to the fact that these islands host diverse and sometimes peculiar species. Despite the ecological significance of the Mediterranean Islands and the pioneer work of Rechinger (1943) followed by the exceptional contribution of Greuter (1991, 1994, 1995, 2001), there have to date been only limited attempts to compare the biogeography of Mediterranean Islands (Médail and Quézel 1997; Delanoë et al. 1996; Mayer 1995; Kuhbier et al. 1984). This mainly reflects the complexity of issues related to Mediterranean Island biogeography and presents a challenge for the future, as suggested by Greuter (2001): *In the Mediterranean the choice is yours: there are about 5000 of them ……. Just define your problem and choose the island or islet tailored to your needs. And remember you may need a boat to get there*.

MacArthur and Wilson's theory (1967) set out to identify and measure the variables involved in the colonisation of islands by biota and their subsequent evolution or extinction. The key biogeographical variables identified by their theory were island size and distance from the mainland. They suggested that an island's biodiversity is proportionate to the island's size (i.e. the larger the island the higher the species number) and inversely proportionate to its distance from the mainland (i.e. more remote islands tend to support less species). Equally significantly they argued that the number of species on an island is in a state of *dynamic* equilibrium – diversity eventually stabilises but turnover remains high as species continually colonise and go extinct. Dynamism is a defining concept when attempting to understand the biogeography of islands and, in the Mediterranean in particular, the impact of human activity over millennia has resulted in very high levels of dynamism with profound consequences for the biota.

This chapter examines this dynamism in relation to some of the generalisations emerging from island biogeography (Table 4.1) and sets them in a Mediterranean context. In particular, the dynamism of Mediterranean Island biota and habitats is discussed including an analysis of the impact of recent, rapid changes in land use and the prospects for the protection of biodiversity and ecological restoration.

Table 4.1 Generalisations emerging from the Theory of Island Biogeography (MacArthur and Wilson 1967)

1. No island has nearly the number of species it would have if it were part of the mainland
2. A large island is likely to have a greater variety of habitats than a small island and therefore contain a greater diversity of species
3. Adaptation to the new environment of the island may be difficult for an immigrant (species) which is usually adapted to mainland conditions
4. The precariousness of some of the ecosystems based on low diversities of flora and fauna makes them susceptible to rapid and sometimes catastrophic change
5. Adaptations to islands take a number of well-known forms such as speciation, adaptive radiation, preservation of 'peculiar' forms of life (giants, flightless birds) due to lack of competition

4.2 Types of Islands

In biogeographical terms two broad types of islands can be distinguished: *continental* and *oceanic*. The former are located over the continental shelf and in the past were connected to the mainland. The latter are found over the oceanic plate and have never been connected to continental land masses (Whittaker 1998). Continental islands are commonly further subdivided into ancient and recent. A third island type commonly referred to in biogeography is *mainland islands*: 'islands' of habitat in a 'sea' or matrix of surrounding often hostile land use. The theory of island biogeography became one of the foundations of landscape ecology (Forman and Godron 1986).

A number of classification schemes for the origin of the Mediterranean Islands have been proposed. The majority are based on a distinction between islands of continental versus oceanic origin (e.g. Greuter 1972; Alcover et al. 1998; Schüle 1993). Islands may have even changed class type in the course of geological time (Marra 2005). This reflects the importance of geology and insularity and there is a time dimension for both. The majority of islands in the Mediterranean are of the continental type since they have been connected to the mainland on several occasions in the geological past (see Chapters 2 and 3). Many Mediterranean Islands are volcanic in origin, most famously and recently Santorini together with Stromboli, the Eolian and the Liparian islands (Schüle 1993). Other volcanic islands are older in origin, shaped by volcanic activity during the Pleistocene (Kos, Ustica, Alicudi, Filicudi) and Holocene (Melos, Salina, Panarea) (Hulme 2004). Continental type islands such as those found in the Mediterranean may shed considerable light on ecological processes (Hulme 2004).

4.3 Mediterranean Island Environments

Throughout the geological history of the Mediterranean Basin islands have changed size, appeared or disappeared altogether, split and reformed as a result of tectonic activity (as described in Chapter 2 and the individual island chapters in this book). The

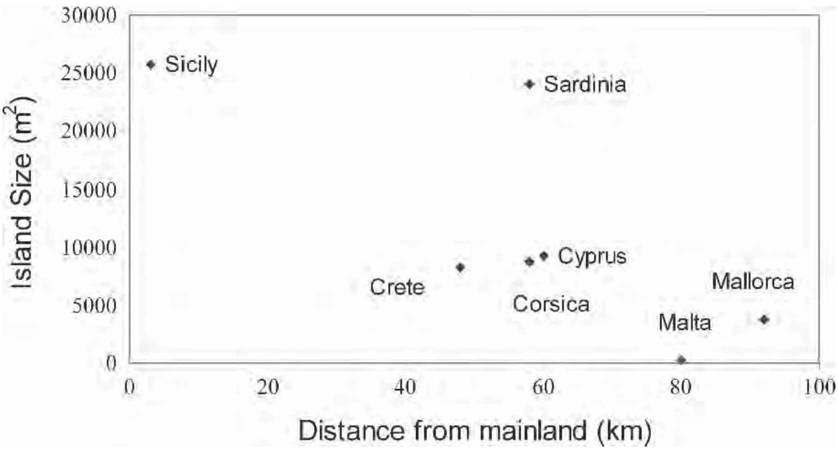

Fig. 4.1 Distribution of the Mediterranean Islands in terms of size and distance from the nearest mainland (After Patton 1996)

Mediterranean contains a complex of islands differing in shape, size, spatial arrangement and distance from the mainland (Fig. 4.1). Examples include large relatively isolated islands such as Cyprus and islands so close to the mainland, such as Sicily, to render insularity almost meaningless. There are large islands with many satellite islets around them (e.g. Sardinia and Crete) and islands in groups of various arrangements: elongated such as the Dodecanese and Ionian islands and the Kornati archipelago in the Adriatic or circular such as the Cyclades and Sporades in the Aegean Sea.

In addition these islands differ in age, isolation, geology and human colonisation history. The 5,000 or so islands present in the Mediterranean Basin display a wide range of sizes from a fraction of 1 km^2 (various islets in the Aegean Archipelagos and Dalmatian coast) to Sicily (25,708 km^2). A range of altitudes is also present from sea level to 3,323 m at Mt. Etna, Sicily. A clear climatic divide exists between the Central-West and East Mediterranean Islands. Summer drought is shorter in the West (Corsica-Sardinia) than the Eastern Mediterranean Islands (e.g. Crete and Cyprus). The Spanish islands of Alboran and Columbretes are among the driest places in Europe compared to islands near the Balkan coast such as Corfu. On islands with steep elevation gradient (e.g. Crete and Sicily) and islands close to high mountains on the mainland (e.g. islands of the Dalmatian coast) the climate is diverse. Due to their complex tectonic history the Mediterranean Islands are equally diverse geologically. Metamorphic substrates are dominant in Corsica and Sardinia, but also present in Sicily and Crete. Calcareous substrates dominate in Crete, Malta and the Balearics.

Palaeoecological and archaeological records indicate a variable pattern in the colonisation of Mediterranean Islands by humans (Chapters 2, 3, 5). At present the inhabited islands vary considerably in terms of average population density. At nearly 100 persons per km^2 island population densities are, on average, twice the

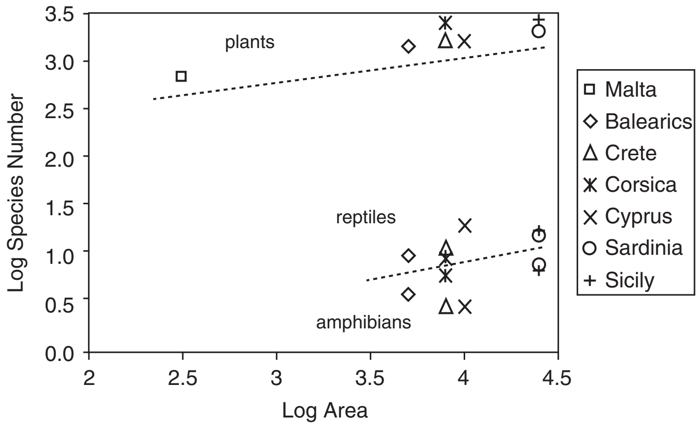

Fig. 4.2 Reptiles, amphibians and plants of the large Mediterranean Islands

average for the entire Mediterranean region. Malta is the extreme with 1,461 persons per km^2 (Chapter 13). There are many other islands that are uninhabited or have been abandoned in the last century. Some are seasonally inhabited during the summer months, e.g. Gaidouronisi near Crete, and others are visited mainly by tourists, e.g. the islands of Palea and Nea Kameni off the island of Santorini. These islands, usually of a small size, outnumber those which are inhabited.

4.4 Mediterranean Island Biogeography

It is widely recognised that the biota present on an island is a function of the island's geological age, spatial and temporal isolation from continental land masses and the length of time since islands were first colonised by humans (Whittaker 1998; Spellerberg and Sawyer 1999). For certain taxa or groups of biota smaller islands generally have fewer species than larger islands (Fig. 4.2). Although many studies have demonstrated the relationship between richness in certain taxonomic groups and area, it is widely accepted that area per se does not determine species richness (Spellerberg and Sawyer 1999). Snogerup and Snogerup (1987) suggest that the number of species in the Aegean increases significantly on islands with a length greater than 500 m and altitude higher than 50 m. The larger islands in the Mediterranean have higher alpha (i.e. numbers of species) and beta (i.e. number of habitats) diversity than islets and therefore host particular communities such as wetlands. Most importantly they are not functionally equivalent in ecological terms to an assemblage of smaller islands totalling the same area (Médail and Vidal 1998). Single islands, island chains and groups of islands may act as barriers or stepping stones for biota facilitating or inhibiting their dispersal. As demonstrated by a study on the island of Hyères in France, for islands close to the mainland the distance/isolation effect seems to influence species composition and relative abundance more than it influences richness while distance between islands played a negligible role in explaining the islands' floristic composition (Médail and Vidal 1998). In theory islands close together should have a more similar flora compared to islands that are distant from each other; this is not always the case due to dispersion difficulties. For example, in the central Aegean distances between islands never exceed 40 km (in some cases less than 10 km) but even this has had an isolating effect acting as a barrier to migration even for light, wind dispersed species (Runemark 1971). Genetic studies indicated that insular populations are genetically less diverse than the populations of their native sources (Blondel and Aronson 1999). Nevertheless Mediterranean Islands have always been a source of genetic variation (López-de-Heredia et al. 2005) and ecological differentiation (Greuter 1995, 2001).

With each human invasion of the islands (see Chapter 3) deliberate and accidental introduction of non-native plants and animals occurred. Some of these species have persisted until today. Examples include the rat (*Rattus rattus)*, house mouse (*Mus musculus)*, and rabbit (*Oryctolagus cuniculus*) while plant species such as *Agave americana, Ailanthus altissima, Carpobrotus edulis, Opuntia ficus-indica, Oxalis pes-caprae* and various *Eucalyptus* species are now part of the Mediterranean landscape.

4.4.1 Vegetation

In general islands share the vegetation types found in the Mediterranean region (Table 4.2) such as forests, open woodlands, maquis, garrigue, phrygana and steppe. Most of these categories occur, often as a mosaic of communities on

Table 4.2 The main vegetation types in the Mediterranean Islands

Term	Definition
Forest	Tree-covered land but can also include other habitats in a matrix of trees
Maquis	A dense mostly evergreen shrub community 1–3 m high characteristic of the Mediterranean region
Garrigue	A community of low scattered often spiny and aromatic shrubs of the Mediterranean region
Phrygana	Low shrub developed over dry stony soil in the Mediterranean region. In general it is an equivalent term to garrigue which is used in the West Mediterranean.
Steppe	Composed of grasses, bulbous and other herbaceous plants
Savanna	A term that denotes big trees widely spaced with an understorey of phrygana or steppe (Grove and Rackham 2001)

Table 4.3 Altitudinal zonation of the Mediterranean vegetation (After Quézel 1981; Thompson 2005)

European region	Mediterranean region	Vegetation formation
	Thermo-Mediterranean zone	Maquis or garrigue
Plains zone	Eu-Mediterranean zone	Maquis or garrigue
Hill zone	Supra-Mediterranean zone	Deciduous oak forests
Montane zone	Montane-Mediterranean zone	Upland coniferous forests
Sub-alpine zone	Lower Oro-Mediterranean zone	Thorny xerophytes
Alpine zone	Upper Oro- or Alti-Mediterranean zone	Dwarf chamaephytes

the larger islands. However, there are many variations between islands with some islands characterised by unique assemblages. Examples include the carob forests in Cyprus, the cork oak forests in Sardinia, valonia oak (*Quercus macrolepis)* forests in Crete, chestnut forests in Corsica and upland hazel groves in Sicily and Sardinia (Barbero et al. 1995). The most widely used altitudinal zonation for Mediterranean vegetation (Table 4.3) proposed by Quézel (1981) is based on latitude, and corresponds to climatic variations, especially temperature. However, it is not applicable to all the Mediterranean Islands since many of them (e.g. Malta) do not have a steep elevation gradient which affects vegetation distribution.

4.4.2 Flora

Mediterranean Island floras are different to the mainland floras, a reflection of their unique natural and cultural characteristics. The flora of the Mediterranean Islands can be classified into three broad categories according to their origin (Greuter 1979): (1) a relict element: ancestors of pre-isolation phase, (2) a telechorous element: resulting from natural long-range dispersal and (3) an anthropic element: human induced. The larger islands in the Mediterranean had significant floristic elements at the time of isolation from the mainland which, until today, have not undergone significant evolutionary change (Greuter 1995). In some cases this flora dates back to the post-Messinian transgression during the Pliocene, that is, some 5–6 million years ago (e.g. Crete, Cyprus). The Messinian Salinity Crisis (see Chapter 2) would have facilitated the interchange of biota between Africa, Asia, Europe and the former (and present) islands. Therefore, and despite the fact that the autochthonous Mediterranean element dominates, floristic elements from all three continents are represented in the islands' flora (Fig. 4.3). In many cases islands represent the southern limits of Circumboreal and northern European elements (Chapter 7) or northern boundaries of many African elements (Chapter 11); while the mountains of east Mediterranean Islands such as Crete support a significant Irano-Turanian element (Vogiatzakis et al. 2003; Kazakis et al. 2007). The floristic affinities between islands reflect their geographical position in the Basin with two

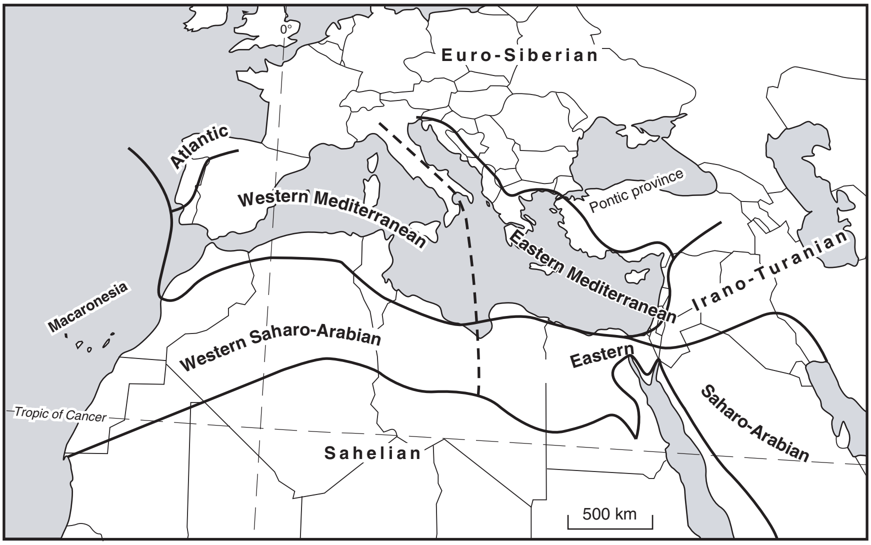

Fig. 4.3 Biogeographical realms in the Mediterranean area (Vogiatzakis et al. 2006)

distinct groups, a western (Tyrrhenian and the Balearics) and an eastern (Aegean, Crete, Cyprus).

Most of the islands in the Mediterranean are biodiversity 'hot spots' (locations of unusually high species diversity according to Médail and Quézel 1997) which have provided refuge for many endemic plant species and contributed to evolutionary differentiation (Greuter 1972, 1979; Snogerup 1985). Many plants have had to adapt to the moisture stress caused by water deficiency across many Mediterranean Islands. The flora of Mediterranean Islands includes several wild relatives of agricultural crops (Heywood 1995). All of the islands examined within this book have been subject to detailed floristic and taxonomical research (Greuter et al. 1984, 1986, 1989) but the continued discoveries of new species (Tzanoudakis and Kypriotakis 1993; Greuter and Strid 1981) and even genera (Egli et al. 1990) suggest that a complete inventory has not yet been achieved.

Most of the large Mediterranean Islands are surrounded by smaller satellite-islets of varying sizes that have been linked to the history and life of the largest islands (Table 4.4). These small islands have generally received less attention than their large counterparts. The islands of the Maltese archipelago are such examples, possibly due to their proximity to Sicily and the Italian mainland and their relative low habitat diversity. On the other hand the Aegean islands are among the best known floristically in the Mediterranean, thanks to the early work of Rechinger followed by Greuter, Runemark and Snogerup. There have always been and still are peculiarities about the floristic composition of the smaller islets and islands. For example, Rechinger and Rechinger-Moser (1951) were the first to recognise that

Table 4.4 Major Mediterranean Islands and their satellite islets

Main island or Archipelagos	Satellite islets
Sicily	Egadi islands, Aeolian Islands, Pelagie Islands*
Sardinia	Asinara, Maddalena, Caprera, Santo Stefano, Spargi, Budelli, Santa Maria, Razzoli San Pietro, San Antioco, Isola dei cavolli
Cyprus	Kila, Glaros, Lefkonisos, Skaloudia, Galounia, Dalmonaris, Kordylia,* Kleides*
Corsica	Iles Sanguinaires,* Iles Lavezzi,* Iles Cerbicale,* Cavallo
Crete	Ghavdos, Dia, Theodorou, Elafonisi, Chrisi, Dionysades,* Koufonisi, Paximadia*
Maltese Archipelago*	Malta, Gozo, Comino
Balearics*	Mallorca, Minorca, Ibiza, Formentera

*Group of islands.

Table 4.5 Globally and locally threatened taxa in the larger Mediterranean Islands (After Delanoë et al. 1996)

	Extinct		Endangered		Vulnerable		Rare		Uncertain		Total		% of island flora	
	Glob	Loc	Glob	Loc	Glob	Loc	Glob	Loc	Glob	Loc	Glob	Loc	Glob	Loc
Sicily	1	1	11	21	26	72	45	76	4	12	87	182	3	6
Sardinia	0	2	11	33	30	64	21	60	1	3	63	162	3	8
Cyprus	0	–	9	11	14	14	22	29	6	7	51	61	3	4
Corsica	1	3	8	146	27	115	10	40	1	1	47	305	2	12
Crete	0	–	11	14	61	73	118	146	3	5	193	238	11	13
Balearics	1	8	10	20	14	34	43	110	1	3	69	175	5	12
Malta	1	84	0	54	1	22	10	108	4	9	16	277	2	28

plant species occurring on small islets in the Aegean Sea were not found in similar habitats in larger islands. Islets often provided a refuge for species that have gone extinct on the larger islands close to them (Blondel and Aronson 1999). Some chasmophytes (not obligate) confined to cliffs on large islands were found colonising different habitats on small islands (Höner and Greuter 1988). This is attributed to the abiotic and biotic similarities of the two environments (e.g. low level interspecific competition, absence of a well developed soil layer, severe drought and extreme daily temperature ranges). Even more peculiar are the reported similarities in the distribution of species between islets off Corsica and large Aegean islands (Blondel and Aronson 1999). Low floristic and biogeographic similarity between neighbouring islets also occurrs, as demonstrated by a comparison of the islet groups of Arki and Lipsi in Dodecanese East Aegean area, Greece (Panitsa and Tzanoudakis 2001).

Despite the long history of botanical recording in the Mediterranean, there is a lack of species distribution and abundance maps which hinders effective conservation and management of flora. The latest assessment of the Mediterranean Islands' Flora (Delanoë et al. 1996) suggests that a significant proportion of the islands' flora is under threat (Table 4.5) from new development, especially coastal tourism, agricultural intensification and climate change. According to Table 4.5 Crete, followed by the Balearics, has the highest percentage (11%) of plants threatened at a global level. The Maltese flora has the highest percentage (28%) of plants threatened at the local level (Table 4.5) reflecting the pressure on the island's habitats (Chapter 13). A recent report from IUCN (De Montmollin and Strahm 2005) identified 50 island plants facing extinction due to their population size and distribution that render them more susceptible than others to disturbance.

4.4.2.1 Endemic Flora

Endemism is present at all taxonomic levels and it owes its origin to a variety of factors such as genetics, ecology, history and their interactions over time (Huston 1994). Endemic species may, therefore, provide insights into biogeographical processes (Myers and Giller 1988). There are two kinds of endemics: palaeo-endemics, ancient vestiges of taxa that were once widespread, and neo-endemics, that is, newly evolved (Kruckenberg and Rabinowitz, 1985). The term sub-endemic is also used for taxa shared between adjacent regions that have been connected in past geological times and therefore exhibit phytogeographic similarities. These may include island connections such as, for example, Sardinia and Corsica (Gamisans 1991), Malta and Sicily (Chapter 13), Crete and Karpathos (Turland et al. 1993) but also island and mainland connections, e.g. Sicily and Calabria, Dodecanese islands and the west coast of Turkey (Davis 1965–1980). These have given rise to distinct phytogeographical regions such as the Balearic-Cyrno-Sardinian (Chapter 10) or the Cardaegean (Greuter 1972). In the Mediterranean small islets have served as natural laboratories of plant evolution while large islands have contributed to the conservation of mid-Tertiary flora with a high degree of endemism (Greuter 1995).

The levels of endemism vary greatly among islands (Table 4.6) with the Balearics having the highest percentage endemism (12.4%) and Malta the lowest (4.6%). Insularity and mountain terrain are considered to be significant causes of high endemism. The best example of their combined influence is the island of Crete with a high relative number of endemics (Table 4.6), many of which are confined

Table 4.6 Islands' size and plant diversity (Delanoë et al. 1996)

Island	Area (km^2)	Species no.	Endemics no.	% Endemism
Sicily	25,708	2700	310	11.5
Sardinia	24,090	2054	200	9.7
Cyprus	9,250	1620	170	10.5
Corsica	8,748	2354	270	11.5
Crete	8,700	1706	200	11.7
Balearics	5,014	1450	180	12.4
Malta	316	700	32	4.6

to the high mountain zones and gorges (Bergmeier 2002; Vogiatzakis et al. 2003). In Corsica it is the middle altitudinal zones that support most of the endemic plant species and this appears to be unrelated to the island's geology (Médail and Verlaque 1997). The presence of endemic trees is also remarkable, particularly on larger islands, and includes fir species *Abies nebrodensis* and *Abies cephalonica* in Sicily and Cephalonia respectively, *Zelkova sicula* in Sicily and *Zelkova cretica* in Crete, *Quercus alnifolia* and *Cedrus brevifolia* in Cyprus (Barbero et al. 1995).

4.4.3 Fauna

The fauna of insular environments is thought to be recruited from the available pool of species on the basis of abundance on the mainland and adaptability of their habitat requirements (Sará and Morand 2002). Schüle (1993) argues that colonisation in Mediterranean Islands by mammals was due to their ability to swim rather than past land connections. Apart from relict species and endemics the biology of island biota often has special features. As discussed in Chapter 2 there are certain faunistic similarities between islands such as dwarf elephants and hippos but also the absence of the elephant–deer assemblage in the case of Corsica-Sardinia complex (Blondel and Aronson 1999). Vera's hypothesis (2000) suggested that large herbivores maintained an open landscape in the primeval landscape of lowland northern Europe. Although this view is now contested by Mitchell (2005), Grove and Rackham (2001) propose that the 'savanna' model might have been the case in Mediterranean Islands since forest reaches its climatic limit.

Although the present day fauna of the Mediterranean Islands is mostly derived from mainland Europe there are elements, particularly in the reptile and amphibian fauna, that indicate affinities with other continents and biogeographical regions. For example, *Chamaeleo chamaeleo* in Sicily, Crete and Cyprus is a tropical relict. Compared to mainland areas in the Mediterranean of similar size, species impoverishment in the islands is 43% and 60% in reptiles and amphibians respectively (Blondel and Aronson 1999). There are more amphibians in western Mediterranean Islands than eastern ones while the reptile fauna includes snakes, lizards and tortoises. Some notable elements include European leaf-toed gecko (*Phyllodactylus europaeus)* in Corsica and Sardinia and the loggerhead turtle (*Caretta caretta)* in Crete, Cyprus, the Ionian islands, but also Sicily and the Balearics.

Large herbivores present currently on larger islands include the mouflon, ibex and deer although most of them were probably introduced (see Chapters 7–13). The presence of marten, weasel, wild pig, fox and wild cat is also common in most of the larger islands. Island insect fauna demonstrate a diverse pattern of species richness reflecting the influence of island area and isolation. Corsica for example has a rich entomofauna often dependent on endemic flora (Médail and Verlaque 1997). Most of the islands are located along principal migratory routes and therefore have a rich bird fauna, especially during the winter. The presence of particular features in some islands contributes further to this richness. For example, the lagoons of

Sardinia host species such as the pink flamingos but also crane, spoonbill, avocet and others. Many islands exhibit a remarkable presence of birds of prey including vultures, eagles, buzzards and falcons. Birds of prey richness patterns in the Mediterranean Islands reflect a distinction between eastern and western islands and corroborate the theory of island biogeography for the importance of island area and accessibility from the continent (Donázar et al. 2005).

4.4.3.1 Endemic Fauna

The Mediterranean Islands are inhabited by several endemic reptile genera such as *Podarcis*, *Lacerta* and *Algyroides* (Gasc et al. 1997) and endemic species such as the Melos viper *Macrovipera schweizeri* (Nilson et al. 1999). Endemic mammals include the spiny mouse *Acomys minous* in Crete and shrew species such as *Crocidura sicula* in Sicily and *Crocidura zimmermani* in Crete. Endemism is generally high in beetles, stoneflies and butterflies in larger islands and may account for 15–20% of the insect fauna (Table 4.7; Blondel and Aronson 1999). Within the bird group and despite their diversity there are few species endemic to Mediterranean Islands. According to Blondel and Aronson (1999) this is because most of the islands are too close to the mainland for differentiation to have had a chance to occur between two colonisation events. Historical factors are the determinants to inter-island differences in endemic fauna as a study in the Balearics by Palmer et al. (1999) revealed.

4.5 Island Landscape Ecology

The Theory of Island Biogeography has also had a profound influence upon theories and models concerning ecological processes in terrestrial environments (Forman and Godron 1986). An 'island' can be defined simply as a habitat that is 'ecologically' isolated often by an inhospitable matrix of intensive agriculture, but

Table 4.7 Endemic reptiles and amphibians in the Mediterranean Islands (After Blondel and Aronson 1999)

	Reptiles		Amphibians	
Island	Total	Endemics	Total	Endemics
Sicily	18	1	7	0
Sardinia	16	3	8	5
Cyprus	21	1	3	0
Corsica	11	3	7	2
Crete	12	0	3	0
Balearics	10	2	4	1

not always. Isolating factors are many and various. Islands, as already pointed out, can be isolated simply as a function of their distance from a 'source' of new colonists; the effective distance will vary between species, with some vagile species able to travel long distances to colonise new sites. In terrestrial environments isolating factors are more complex: habitats and species are more or less isolated depending upon distance, climatic, geological, geomorphological and altitudinal factors. In the Mediterranean context, cliff faces, scree slopes, gorges, mountain summits can all be effectively isolated for large numbers of plants, especially, and animals. A good example are the mountain summits of the Lefka Ori in Crete; here there are high levels of endemism in this Oro-Mediterranean zone since the high mountain peaks remained isolated even during the Miocene when subsidence caused the break up and resubmergence of most of the Aegean landmass. Equally important however, is the isolating impact of human activity; areas of phrygana, for example, becoming functionally isolated (beyond the dispersal capacity of many species) with the encroachment of olive production or other forms of modern, intensive agriculture.

By contrast, the degree of isolation of habitats on Mediterranean Islands may be ameliorated by 'connections' many of which are an integral part of the farmed landscapes. Typical examples in a Mediterranean context include field boundaries, particularly stone walls, terraces, many now abandoned and returning to garrigue and irrigation channels (Kizos and Koulouri 2006). In Malta *widien* are water run-off channels formed by either stream erosion during a former wetter regime or by tectonic movements. Where *widien* are fed by perennial springs the vegetated water course forms a natural connection for plants and animals between otherwise 'isolated' fragments of garrigue scrub in an otherwise dry and water stressed landscape. Artificial (human-made) corridors in the landscape also have a role to play in species distribution as exemplified by the case of the invasive tree *Ailanthus altissima* in Crete which is associated with the main transport network of major roads (Hulme 2004).

Recent work in landscape ecology (Wiens and Moss 2005) has formalised the spatial pattern of habitat islands and their connections within a frequently inhospitable matrix into: habitat, conduit, filter, source and sink. In the human dominated landscapes of the majority of Mediterranean Islands, virtually all natural habitats are destined to resemble islands in that they will eventually become isolated fragments of formerly much larger continuous natural habitat. Whilst Grove and Rackham (2001) among others have cast doubt on the orthodoxy of 'ruined landscape theory' (the theory that suggests almost catastrophic and wholesale denudation of Mediterranean forests), there is no doubt that the human impacts of development, most recently as a result of rapid urban expansion and tourism pressure, and intensive agriculture, have served to fragment former much larger areas of habitat into small, remnant patches. In landscape ecological terms such patches can serve as conduits for the movement of species, as filters inhibiting the movement of some species and facilitating that of others, as sources of species for the colonisation of other patches and as 'sinks'. The ecology of corridors remains contentious with some suggestions that a corridor simply serves to increase the total area of 'habitat' in the landscape whilst others counterclaim that linear connections between patches operate as conduits, linking otherwise isolated patches in a functioning ecological network allowing for the dispersal of plants and animals (Bennett 2003). There are many examples of ecological corridors in a Mediterranean context at a wide range of scales from the micro-scale already discussed (terraces, stone walls) to the macro, whole island scale of 'greenways' (Jongman and Pungetti 2004).

Landscapes are increasingly regarded in an integrative and holistic way as … *total space/time defined concrete ecological, geographical and cultural systems* (Naveh 1990). Therefore Naveh (1994, 2000) advanced the idea for a holistic approach to the conservation of both the natural and cultural assets of a region's landscape (Farina and Naveh 1993; Green and Vos 2001). According to these studies the following cultural landscapes are threatened in the Mediterranean Basin:

- Relict natural landscapes which consist of remnants of relatively undisturbed ecosystems where agriculture is limited due to physiography/topography (Vos 2001)
- Vanishing traditional landscapes which were originally oriented towards subsistence agriculture as for example, the wooded pastures (*montados* and *dehesas*) in Portugal and Spain (Pinto-Correia 2000) also abundant in Sardinia.
- Stressed landscapes comprise large-scale agricultural landscapes with an increasingly intensive land use as in Western Crete (Rackham and Moody 1996)

In many situations where agriculture has been important for long periods the ecological interest is richest in the cultural elements in the landscape which include terraces, stone walls and other field boundaries. Land abandonment however, is having a profound impact on the ecological characteristics of the agricultural landscape with terraces and walls falling into disuse and fields reverting to early succession Mediterranean scrub (Grove and Rackham 2001).

Habitat patches operating as sources versus sinks of species is a complex topic and it remains difficult to quantify the ecological function of a patch in this context. The Theory of Island Biogeography is unhelpful in this respect since it does not provide all the answers. For example, how large does a patch have to be to act as a source? For which species is this true and surrounded by what type of land use matrix? Despite a long history of management for cork production the extensive cork oak (*Quercus suber*) forests of Sardinia are large enough to act as reservoirs for a wide range of species capable of dispersing into the surrounding landscape. In other parts of the Mediterranean the combined impact of grazing, fire and development has effectively isolated fragments of scrub such that they become ecologically isolated and no longer operate as part of a functioning ecological network.

This type of analysis has important implications for the selection of sites for nature protection, management and restoration of existing sites and for the recreation of lost habitats. Important in this respect is the Habitats Directive (Council of Europe 1992) and the establishment of the pan European network of protected sites

(Natura 2000). The Directive establishes a European ecological network known as 'Natura 2000' comprising 'Special Areas of Conservation' and 'Special Protection Areas' (for the conservation of wild birds) designated by Member States in accordance with the provisions of the Directive. Effective protection is likely to be best achieved from a network of large, well-connected habitats. However, the danger of such an approach is that small sites are overlooked resulting in risks to the future of isolated populations of important endemic species. Techniques are required for the ecological evaluation of sites. Recent work (Boteva et al. 2004) has demonstrated the implementation of the Ratcliff (1977) criteria within a GIS environment for evaluating the ecological quality of a Natura 2000 site on Crete. The assessment identified and scored the most valuable communities within the protected area using the most frequently used criteria for nature conservation. The final conservation score for each community was derived using Multiple Criteria Evaluation within a GIS. The results demonstrated that the method is an effective tool for evaluating and comparing conservation significance and could be applied to other sites across the Mediterranean.

Very little work has been undertaken on habitat restoration and recreation, either in a theoretical or practical sense, in Mediterranean landscapes (Naveh 1988, 1994, 1998). GIS modelling techniques are now well developed and can be used to identify potential sites for habitat re-creation based upon landscape ecological principles. Such techniques rely upon reliable and up to date maps of the type and extent of habitats and knowledge about the dispersal strategies and distances of a range of species, information that is often lacking.

4.6 Conservation on Islands

The combination of endemism and high species richness has resulted in the majority of Mediterranean Islands being recognised as global biodiversity hotspots (Davis et al. 1994; Médail and Quézel 1997). An island is a constrained system which imposes restrictions on biotope area. Island flora is therefore fragile and vulnerable compared to mainland flora (Snogerup 1985; Heywood 1995). Rackham and Moody (1996) contest this in the context of Crete since the island has retained its indigenous plants and the soil is not irreversibly degraded. The designation of Natural Protected Areas in the Mediterranean Islands (Chapter 6) has contributed to conservation efforts, sometimes contradictory and conflicting (see Chapter 11). Indeed, there is much variation between Mediterranean Islands in terms of the level and extent of protected area reflecting the uneven approach to conservation that characterises Mediterranean countries.

The approach taken so far towards nature/landscape conservation has followed established and widely adopted methods. The ecosystem-based approach has been advocated in the Mediterranean because it ensures the protection of species' genetic diversity and the ecological processes essential for species survival (Greuter 1974; Blondel and Aronson 1999). This is of utmost importance particularly for endemic species due to their high ecological specialisation and the lack of competitiveness (Médail and Verlaque 1997). However, it is widely recognised that biodiversity conservation cannot be achieved by concentrating efforts solely on habitats and species within protected areas. This is because many processes affecting species survival operate at a scale beyond the protected areas boundaries (i.e. the landscape).

Although there are examples of islands with a large proportion of their total surface area under protection such as Corsica (Chapter 10) and the Balearics (Chapter 12), the Kornati archipelago in the Adriatic is the most extensive National Park in the Mediterranean that encompasses a high number of islands (89 islands, islets and reefs along 238 km of coastline) in a total area of c.220 km^2. Special protection measures are advocated particularly for the islets in the Mediterranean since their flora is at significant risk (Greuter 1995).

During the course of evolution extinction has been a common and natural phenomenon. However, the 20th century has witnessed the most far-reaching ecological change in the history of humanity. The Mediterranean flora has to a degree adapted to the destructive actions of humans. The present extinction rate of Mediterranean higher plants is 0.1% (i.e. 37 species presumed to be extinct), while 4,251 taxa are considered to be under threat (Greuter 1994). This leads to the conclusion that although the present loss appears to be tolerable, future extinction might be on a substantial scale. A recent assessment on global imminent extinctions includes two Mediterranean Islands (Ricketts et al. 2005). The most important factor that will determine the future of island flora is human activity. Although these activities are similar to those observed in the mainland Mediterranean region they are usually amplified because of insularity. Despite the range of conservation efforts their efficiency for the long term management and protection of Mediterranean biodiversity in the light of future climatic changes is questioned (Allen 2003). The risk for endemic species in particular is expected to be higher as altitude increases since important habitats will be rendered unsuitable at these zones for some species. In Crete, for example, preliminary results suggest that certain species might be in risk of extinction in the high mountain zones (Kazakis et al. 2007) while similar cases are reported from Cyprus (Section 9.3). However, Médail and Verlaque (1997) suggest that the mountain flora in Corsica is in less danger since both endemics and pressures are concentrated at mid altitudes (800–1,700 m).

Mediterranean Islands have always been very vulnerable to invasion by exotic species. Whereas the proportion of the flora of the Mediterranean Basin composed of exotics is only 1% it is substantially higher for Mediterranean Islands (>10%) (Hulme 2004). The devastation of island ecosystems worldwide has raised awareness about the global threat that human-driven species dispersal is posing for biological diversity. With every human invasion of the islands (see Chapter 3) deliberate and accidental introduction of non-native plants and animals occurred (Azzaroli 1981; Grove and Di Castri 1991). The introduction of alien predators has, in the past, led to adverse effects on various trophic levels of island ecosystems and eventually species extinction (Palmer and Pons 1996; Riela et al. 2002). It is highly likely that future global warming will favour non-native species, e.g. *Opuntia ficus-indica* and *Acacia dealbata* (Hulme 2004; Gritti et al. 2006). There remains a strong interest in predicting potential impacts of rapid, anthropogenic climate change on the biota of Mediterranean Islands.

4.7 Conclusion

The complex geological evolution of Mediterranean Islands combined with the more recent impact of human activity, has resulted in the biogeographical patterns that we see today. Many of these patterns conform to theory with islands displaying, for example, high levels of endemism and the effects of isolation. The profound impact of human activity over millennia however, tends to obscure and confound many of the underlying patterns and this has enriched the biota on some islands and impoverished it on others.

An understanding of the underlying causes of species distribution across Mediterranean Islands is critically important if we are to maintain and enhance ecologically important habitats and protect species. Biogeography has an important role to play in this respect but much more knowledge of the habitat preferences of species and their response to habitat fragmentation resulting from increasing development pressures and climate change is required. In particular, very little is known about the dispersal capability of species, both plants and animals, and this will be of vital importance if strategies to combat the potentially adverse effects of climate change are to be accommodated. Landscape ecology will play an increasingly important role in this respect, providing the spatial context within which to select ecologically important sites for protection, for monitoring change and for identifying sites for habitat restoration and re-creation.

References

Alcover, J.A., Sans, A. and Palmer, M. (1998) The extent of extinction of mammals on islands. Journal of Biogeography 25: 913–918.

Allen, H.D. (2003) Response of past and present Mediterranean ecosystems to environmental change. Progress in Physical Geography 27: 359–377.

Azzaroli, A. (1981) Cainozoic mammals and the biogeography of the Island of Sardinia, western Mediterranean Palaeogeography, Palaeoclimatology, Palaeoecology 36: 107–111.

Barbero, M., Loisel, R. and Quézel, P. (1995) Les essences arbores des îles mediterranennes: leur role écologique et paysager. Ecologia Mediterranea 21: 53–69.

Bennett, A.F. (2003) Linkages in the Landscape: The Role of Corridors and Connectivity in Wildlife Conservation. IUCN.

Bergmeier, E. (2002) The vegetation of the high mountains of Crete: a revision and multivariate analysis. Phytocoenologia 32(2): 205–249.

Blondel, J. and Aronson, J. (1999) Biology and Wildlife of the Mediterranean Region. Oxford University Press.

Boteva, D., Griffiths, G.H. and Dimopoulos, P. (2004) A method for the evaluation and mapping of the nature conservation significance of habitats using GIS: an example from Crete, Greece. Journal for Nature Conservation 12: 237–250.

Council of Europe (1992) Council Directive 92/43 EEC of 21 May 1992 on the Conservation of Natural Habitats and Wild Fauna and Flora. O.J. Eur. Comm. No. L206/7: 7–50.

Darwin, C. (1859) On the Origins of Species By Means of Natural Selection. J. Murray: London.

Davis, P.H. (ed.) (1965–1980) Flora of Turkey and the East Aegean Islands, Vols. I–X. Edinburgh University Press.

Davis, S.D., Heywood, V.H. and Hamilton, A.C. (eds.) (1994) Centres of Plant Diversity. WWF/IUCN: Cambridge.

Delanoë, O., De Montmollin, B. and Olivier, L. (1996) Conservation of the Mediterranean Island plants. 1. Strategy for Action. IUCN: Cambridge.

De Montmollin, B. and Strahm, W. (eds.) (2005) The Top 50 Mediterranean Island Plants. IUCN/SSC Mediterranean Islands Plant Specialist Group.

Donázar, J.A., Gangoso, L., Forero, M.G. and Juste, J. (2005) Presence, richness and extinction of birds of prey in the Mediterranean and Macaronesian islands. Journal of Biogeography 32: 1701–1713.

Egli, B., Gerstberger, P., Greuter, W. and Risse, H. (1990) *Horstrissea dolinicola*, a new genus and species of umbels (*Umbelliferae, Apiaceae*). Wildenowia 19: 389–399.

Farina, A. and Naveh, Z. (eds.) (1993) Landscape Approach to regional planning: The future of the Mediterranean Landscapes. Special Volume. Landscape and Urban Planning 24.

Forman, R.T.T. and Godron M. (1986) Landscape Ecology. Wiley: New York.

Gamisans, J. (1991) La Végétation de la Corse. Conservatoire et Jardin botaniques de la ville de Genève.

Gasc, J.P., Cabela, A., Crnobrnja-Isailovic, J., Dolmen, D., Grossenbacher, K., Haffner, P., Lescure, J., Martens, H., Martvnez Rica, J.P., Maurin, H., Oliveira, M.E., Sofianidou, T.S., Veith, M. and Zuiderwijk, A. (eds.) (1997) Atlas of amphibians and reptiles in Europe. Collection Patrimoines Naturels 29, Societas Europaea Herpetologica, Muséum National d'Histoire Naturelle & Service du Patrimoine Naturel, Paris, 496 pp.

Grant, P.R. (1998) Evolution on Islands. Oxford University Press.

Green, B. and Vos, W. (2001) Threatened Landscapes: Conserving Cultural Environments. Spon Press: London.

Greuter, W. (1972) The relict element of the flora of Crete and its evolutionary significance. In V.H. Valentine (ed.) Taxonomy, Phytogeography and Evolution. Academic Press: London, pp. 161–177.

Greuter, W. (1974) Floristic report on the Cretan area. Memorias da Sociedade Broteriana 24: 131–171.

Greuter, W. (1979) The origins and evolution of island floras as exemplified by the Aegean Archipelago. In D. Bramwell (ed.) Plants and Islands. Academic Press: London, pp. 87–106.

Greuter, W. (1991) Botanical diversity, endemism, rarity and extinction in the Mediterranean area: an analysis based on the published volumes of Med – Checklist. Botanika Chronika 10: 63–79.

Greuter, W. (1994) Extinctions in the Mediterranean areas. Philosophical Transactions of the Royal Society London B 344: 41–46.

Greuter, W. (1995) Origin and peculiarities of Mediterranean Island floras. Ecologia Mediterranea 21: 1–10.

Greuter, W. (2001) Diversity of Mediterranean Island floras. Bocconea 13: 55–64.

Greuter, W. and Strid, A. (1981) Notes on Cardaegean plants. 2. A new species of *Ranunculus* sect. *Ranunculus* from the mountains of Kriti. Wildenowia 11: 267–269.

Greuter, W., Burdet, H. and Long, G. (eds.) (1984, 1986, 1989) Med – checklist. A Critical Inventory of Vascular Plants of the Circum – Mediterranean Countries. Conservatoire et Jardin Botaniques de la Ville de Genève, Genève.

Gritti, E.S., Smith, B. and Sykes, M.T. (2006) Vulnerability of Mediterranean Basin ecosystems to climate change and invasion by exotic plant species. Journal of Biogeography 33: 145–157.

Grove, R.H. and Di Castri, F. (1991) Biogeography of Mediterranean invasions. Cambridge University Press: Cambridge.

Grove, A.T. and Rackham, O. (2001) The Nature of the Mediterranean Europe. Yale University Press: New Haven, CT.

Heywood, V.H. (1995) The Mediterranean flora in the context of world biodiversity. Ecologia Mediterranea 21(1/2): 11–18.

Höner, D. and Greuter, W. (1988) Plant population dynamics and species turnover on small islands near Karpathos (South Aegean, Greece). Vegetatio 77: 129–137.

Huggett, R.J. (1998) Fundamentals of Biogeography. Routledge: London.

Hulme, P.E. (2004) Islands, invasions and impacts: a Mediterranean perspective. In J.M. Fernández-Palacios and C. Morici (eds.) Ecología Insular/Island Ecology. Asociación Española De Ecología Terrestre, pp. 359–383.

Huston, M.A. (1994) Biological Diversity: The Co-existence of Species in Changing Landscapes. Cambridge University Press: Cambridge.

Jongman, R.H.G. and Pungetti, G. (2004) Ecological Networks and Greenways: Concept, Design, Implementation. Cambridge University Press.

Kazakis, G., Ghosn, D., Vogiatzakis, I.N. and Papanastasis, V.P. (2007) Vascular plant diversity and climate change in the alpine zone of the Lefka Ori, Crete. Biodiversity and Conservation. 16: 1603–1615.

Kizos, Th. and Koulouri, M. (2006) Agricultural landscape dynamics in the Mediterranean: Lesvos (Greece) case study using evidence from the last three centuries. Environmental Science and Policy 9: 330–342.

Kruckenberg, A.R. and Rabinowitz, D. (1985) Biological aspects of endemism in higher plants. Annual Review of Ecology and Systematics 16: 447–479.

Kuhbier, H., Alcover, J.A. and D'Arellano, G. (eds.) (1984) Biogeography and Ecology of the Pityusic Islands. Dr. W. Junk Publishers: The Hague.

López-de-Heredia, U., Jiménez, P., Díaz-Fernández, P. and Gil, L. (2005) The Balearic Islands: a reservoir of cpDNA genetic variation for evergreen oaks. Journal of Biogeography 32: 939–949.

MacArthur, R.H. and Wilson, E.O. (1967) The Theory of Island Biogeography. Princeton University Press: Princeton, NJ.

Marra, A.C. (2005) Pleistocene mammals of Mediterranean Islands. Quaternary International 129: 5–14.

Mayer, A. (1995) Comparative Study of the Coastal Vegetation of Sardinia (Italy) and Crete (Greece) with Respect to the Effects of Human Influence. IHW-Verlag: Eching bei München.

Médail, F. and Quézel, P. (1997) Hot-spots analysis for conservation of plant biodiversity in the Mediterranean Basin. Annals of the Missouri Botanical Gardens 84: 112–127.

Médail, F. and Verlaque, R. (1997) Ecological characteristics and rarity of endemic plants from southeastern France and Corsica: Implications for biodiversity conservation. Biological Conservation 80: 269–281.

Médail, F. and Vidal, E. (1998) Organisation de la richesse et de la composition floristiques d'îles de la Méditerranée occidentale (sud-est de la France). Canadian Journal of Botany 76(2): 321–331.

Mitchell, F.J.G. (2005) How open were European primeval forests? Hypothesis testing using palaeoecological data. Journal of Ecology 93: 168–177.

Myers, A.A. and Giller, P.S. (eds.) (1988) Analytical Biogeography: An Integrated Approach to the Study of Animal and Plant Distributions. Chapman & Hall: London.

Naveh, Z. (1988) Multifactorial reconstruction of semi-arid Mediterranean landscapes for multipurpose land uses. In E. Allen (ed.) The Reconstruction of Disturbed Arid Lands: An Ecological Approach. Westview Press: Boulder Col., pp. 234–256.

Naveh, Z. (1990) Ancient man's impact on the Mediterranean landscape in Israel – ecological and evolutionary perspectives. In S. Bottema, G. Entjes-Nieborg and W. Van Zeist (eds.) Man's Roles in the Shaping of the Eastern Mediterranean Landscape, pp. 43–50.

Naveh, Z. (1994) From biodiversity to ecodiversity – a landscape ecological approach to conservation and restoration. Restoration Ecology 2: 180–189.

Naveh. Z. (1998) Ecological and cultural landscape restoration and the cultural evolution towards a post-industrial symbiosis between human society and nature. Restoration Ecology 6: 135–143.

Naveh, Z. (2000) What is holistic landscape ecology? A conceptual introduction. Landscape and Urban Planning 50: 7–26.

Nilson, G., Andrén, C., Ioannidis, Y. and Dimaki, M. (1999) Ecology and conservation of the Milos viper, *Macrovipera schweizeri* (Werner, 1935) Amphibia Reptilia 20, 355–375.

Palmer, M. and Pons, G.X. (1996) Diversity in West Mediterranean islet: effect of rat presence on a beetle guild. Acta Oecologica 17: 297–305.

Palmer, M., Pons, G.X., Cambefort, I. and Alcover, J.A. (1999) Historical processes and environmental factors as determinants of inter-island differences in endemic faunas: the case of the Balearic Islands. Journal of Biogeography 26: 813–823.

Panitsa, M. and Tzanoudakis, D. (2001) A floristic investigation of the islet groups Arki and Lipsi (East Aegean Area, Greece). Folia Geobotanica 36: 265–279.

Pinto-Correia, T. (2000) Future development in Portuguese rural areas: how to manage agricultural support for landscape conservation? Landscape & Urban Planning 50, 95–106.

Quézel, P. (1981) The study of groupings in the countries surrounding the Mediterranean: some methodological aspects. In F. Di Castri, D.W. Goodall and R.L. Sprecht (eds.) Mediterranean-type Shrublands. Elsevier: Amsterdam, pp. 87–93.

Rackham, O. and Moody, J.A. (1996) The Making of the Cretan Landscape. Manchester University Press: Manchester.

Ratcliff, D. (ed.) (1977). A Nature Conservation Review: The Selection of Sites of National Importance to Nature Conservation in Britain. Cambridge University Press, 401 p.

Rechinger, K.H. (1943) Flora Aegea. Akad. Wiss. Wien, Math.-Naturwiss. Kl., Denkschr. 105(1).

Rechinger, K.H. and Rechinger-Moser, F. (1951) Phytogeographia Aegaea. Akad. Wiss. Wien, Math.-Naturwiss. Kl., Denkschr. 105(2): 1–208.

Ricketts, T.H. et al. (2005) Pinpointing and preventing imminent extinctions. PNAS 102(51): 18497–18501.

Riela, N., Traveset, A. and Garcia, O. (2002) Breakage of mutualisms by exotic species: the case of *Cneorum tricoccon* L. in the Balearic Islands (Western Mediterranean Sea). Journal of Biogeography 29: 713–719.

Runemark, H. (1971) Distributional patterns in the Aegean. In P.H. Davis, P.C. Harper and J.C. Hedge (eds.) Plant Life of S.W. Asia. Botanical Society of Edinburgh, pp. 3–12.

Sará, M. and Morand, S. (2002) Island incidence and mainland population density: mammals from Mediterranean Islands. Diversity and Distributions 8: 1–9.

Schüle, W. (1993) Mammals, vegetation and the initial human settlement of the Mediterranean Islands: a palaeoecological approach. Journal of Biogeography 20: 399–411.

Snogerup, S. (1985) The Mediterranean Islands. In C. Gomez-Campo (ed.) Plant Conservation in the Mediterranean Area. Dordrecht, pp. 159–173.

Snogerup, S. and Snogerup, B. (1987) Repeated floristical observations on islets in the Aegean. Plant Systematics and Evolution 155:143–164.

Spellerberg, I.F. and Sawyer, J.W.D. (1999) An introduction to applied biogeography. Cambridge University Press: New York.

Stuessy, T.F. and Ono, M. (eds) (1998) Evolution and Speciation of Island Plants. Cambridge University Press: New York.

Thompson, J.D. (2005) Plant Evolution in the Mediterranean. Oxford University Press, p. 293.

Turland, N.J., Chilton, L. and Press, J.R. (1993) Flora of the Cretan area. Annotated Checklist and Atlas. HMSO: London.

Tzanoudakis, D. and Kypriotakis, Z. (1993) *Allium platakisii*, a new species of the Greek insular flora. Flora Mediterranea 3, 309–314.

Vera, F.W.M. (2000) Grazing Ecology and Forest History. CABI: Wallingford, CT.

Vogiatzakis, I.N., Griffiths, G.H. and Mannion, A.M. (2003) Environmental factors and vegetation composition Lefka Ori massif, Crete, S. Aegean. Global Ecology and Biogeography 12: 131–146.

Vos, W. (2001) The Solano Basin, Italy. In B. Green and W. Vos (eds.) Threatened Landscapes: Conserving Cultural Environments. Spon Press: London, pp. 91–99.

Wallace, A.R. (1892) Island Life: Or the Phenomena and Causes of Insular Faunas and Floras Including a Revision and Attempted Solution of the Problem of Geological Climates. Macmillan: London.

Whittaker, R.J. (1998) Island Biogeography. Oxford University Press: Oxford.

Wiens, J.A. and Moss, M.R. (eds.) (2005) Issues and Perspectives in Landscape Ecology. Cambridge University Press.

Chapter 5
Cultural Landscapes of Mediterranean Islands

Th. Papayannis and A. Sorotou

The town (*chora*) of Kea Island with terraces for cultivation (Photo: Th. Papayannis)

5.1 The Notion of Cultural Landscape

'Everything about human history is rooted in the earth, which has meant that we must think about habitation' (Said 1994, p. 7). Edward W. Said might have used the above phrase within a context of analysis of the relation between geography and imperialistic power, but he managed to summarise in 18 words what others analysed in volumes: the past, the present and the future of *anthropos* (the Greek word

Mediterranean Institute for Nature and Anthropos (Med-INA), Greece

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for human) was, is and will be always depicted on the landscape. The landscape is a result of the interaction between humankind and nature. It is also the lived context experienced and perceived by human beings. Therefore, in essence, all landscapes are cultural. This particular perception and experience is extremely valuable in determining human attitudes towards the continuum of space and time. Consequently, the landscape gains its structure from the human activities, which are carried out within a given environment and through the landscape itself, and therefore it is as much a process as it is an entity (Zedeño 2000). The term cultural landscape has been used in a variety of ways from different disciplines and in different continents (for a review, see Jones 2003). In the Mediterranean Basin, Naveh (1990, 1998a, b) pioneered the holistic landscape paradigm (see Chapter 14) in the context of cultural landscapes. For Naveh (1995) cultural landscapes are '… a tangible meeting point between nature and mind'.

When analysing the concept of cultural landscape further, the physical and the symbolic interconnection between culture and landscape becomes evident. First, landscape is more or less the space where people perform their everyday tasks. Second, land, the ancient Greek *topos*, may be considered to embody ancestral energies, spiritual forces, memories, dreams and identities. It is possible that the same location may effectively be a different place for two different persons, especially if they originate from different cultural backgrounds. Cultural landscapes, which comprise a mixture of everything that goes with a living space, are to be found everywhere in the world. Even areas of exceptional natural beauty that were until recently thought to be *untouched* by humans have often proved to have long been inhabited and altered.

The Mediterranean would not be the way it is today if islands did not exist. Small or large, inhabited or uninhabited, with high or low vegetation, the islands are distinctive features of the Mediterranean region. They definitely 'make up a coherent human environment in so far as pressures are exerted upon them, making them both far ahead and far behind the general history of the sea' (Braudel 1966, p. 150). Throughout their history some islands acted as great centres and others just as *stepping stones*, but all of them existed and functioned within a maritime network, *a coherent human environment* that brought in contact great civilisations, powerful empires and three major continents: Europe, Asia and Africa.

The geological formation of islands from the Pleistocene onwards, the environmental conditions, the movement of animal and plant species from the surrounding continents and the cultural dynamics of human populations have fundamentally shaped the landscapes of the islands. Although today the local as well as the global pressures (unsustainable tourism, abandonment of traditional activities, high degree of building construction, etc.) can be catastrophic for the island-landscape fabric, the relative physical isolation and insularity of island societies in the past fostered the development of distinctive cultures and the creation of unique beauty and topography. Despite the results of anthropic actions, places and features of cultural significance definitely persist as powerful expressions of the way that the Mediterranean islanders perceived, shaped and interacted with their topography and resources.

Returning to the issue of insularity, several controversial issues emerge, especially when the matters of perception and experience are considered. Broodbank (2000) suggests that there are more 'flexible approaches' to insularity. Islands are not just land; they are surrounded also by sea. Instead of examining the landscape alone, it is equally useful to explore the perceptions and use of the seascape. The opportunities of an island might after all have attracted several diverse cultural groups or the potential risks of another might have repelled them. The sea enables relatively rapid movement and encourages the communication and exchange between islands. The sea, therefore, is of considerable importance to the island inhabitants; inevitably islands play an important role in the use that islanders are making of them and in the general perception of their topography.

5.2 Human Use and Habitation of the Mediterranean Islands

Islands were among the last parts of the globe to be settled. Nonetheless, island life has been an essential part of human history for at least the last 40,000 years (Gamble 1979; Broodbank 2000). John Cherry (1990 and elsewhere) has completed a pioneering research on the colonisation of the Mediterranean Islands that despite the recent data from the archaeological field, remains a very robust model. The general pattern that he identified on island colonisation relates to three general characteristics: island size, distance from mainland and configuration (Broodbank 2000). His main argument firstly was that many of the Mediterranean Islands, if not all, were being explored and their resources exploited long before the first settlements on their lands. Secondly, he claimed that instead of large waves of immigrants, small groups of peoples initially settled on the islands.

An interesting example is the case of the island of Melos and the Melian obsidian. According to the archaeological data, the distribution of Melian obsidian extended from Crete to Macedonia as early as the sixth millennium BC. In southern Argolid, in the Francthi cave, Melian obsidian was recovered in layers dating back to 7500 BC. However a survey on Melos, which was an island even in late Pleistocene times, suggested that there was not any kind of settlement before the fifth millennium BC, while it was not permanently inhabited before the Bronze Age. So the acquisition of obsidian was not a result of a trade exchange between populations of the mainland and Melians, but rather a straight acquisition of the material by the mainlanders directly from its source.

Another example of island resource exploitation before permanent human settlement comes from the site of Aetokremmos, on the Akrotiri Peninsula of southern Cyprus, where bones of pygmy hippopotamus were found with features and artefacts indicating that the species was exterminated by humans around 9700 BC. Settlement on the island had been established at Khirokitian much later, at 7000 BC.

The permanent settlement of human populations, of course, whenever formally occurring, was a turning point in the formation of the Mediterranean Island landscape.

Apart from hunting processes that led to extinction of endemic species, humans also introduced new domestic and sometimes competing species. In Corsica, for example, two factors brought about the extinction of endemic animals: the introduction of dogs, which brought about the demise of the large rodents, the insectivores and *Prolagus* and the introduction of competing species of small animals such as shrew, field mouse, house mouse and rat (Davis 1987).

5.3 Anthropic Impact and the Formation of the Cultural Landscape

Human actions and perceptions are inextricably linked to the notion itself of cultural landscapes (Zedeño 2000). It is important, therefore, to identify the specific anthropic impacts that have formed –and transformed through the ages – cultural landscapes in the Mediterranean Islands. Nevertheless, island landscapes, as seen today, are subject to contemporary anthropogenic transformations, influenced not only by local but also by global culture. In this section, the impacts of traditional societies are briefly presented, while in the next one those of contemporary activities.

5.3.1 Hunting and Foraging

During this initial phase, as referred to above, human actions impacted indirectly only on landscapes, through the elimination of large animals from most islands. This led to changes in vegetation and established the present ecology of islands (Diamond 1998).

5.3.2 Traditional Primary Activities

Once human beings became settled, their primary activities had direct impact on landscapes. The need of land for cultivation, often in rocky and steeply sloping islands, combined with a strongly seasonal climate, led firstly to wide exploitation of all cultivable land (Fig. 5.1) and secondly to a system of extensive bench terracing, which is still evident in many Mediterranean Islands. A very good example of extensive exploitation of the available cultivable land is the case of the southern slopes of the Troodos mountains in Cyprus, where the landscape has been farmed for more than 5,000 years (Renden 1997). The construction and maintenance of these terraces ranged from simple to quite sophisticated structures, which required considerable human labour (Fig. 5.2). They were made possible (and necessary) by the large numbers of inhabitants in many islands. For example, the island of Kea in the Cyclades had a population in antiquity estimated at 50,000, while today there are only 1,400 permanent inhabitants.

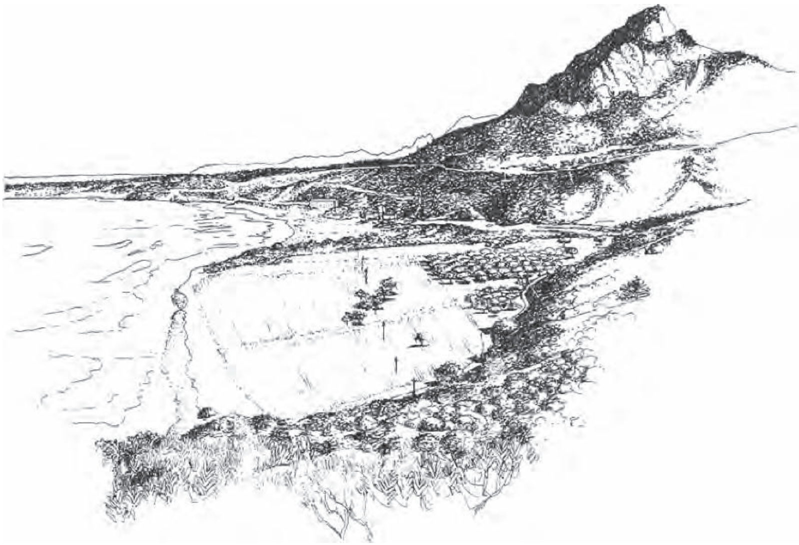

Fig. 5.1 Mediterranean rural landscapes in the Kyrenia region in Cyprus (Makhzoumi and Pungetti 1999. Reproduced with permission from Routledge)

Fig. 5.2 Terraces in Ambelos on the island of Gavdos south-west of Crete (Photo courtesy of G. Kazakis (*See Colour Plates*))

The terracing was a very effective method of combating soil erosion and retaining water during the summer months. The low dry walls that made terraces possible were also a means to dispose of stones and clear the resulting fields. Today, with the decrease of farming populations, there is insufficient labour to maintain the terraces; they are slowly disappearing from island landscapes and thus reducing the capacity to control soil erosion. Consequently, this has caused loss of the organic content, reduction of soil moisture storage, soil cohesion, structural properties and infiltration rates, while maquis soon re-established itself on the abandoned terraces (Faulkner and Hill 1997). A typical example is the case of the seven Aeolian Islands, in the Tyrrhenian Sea, where terraces built for olive cultivation are only visible today in the islands of Alicudi, Filicudi, Salina and Stromboli; the situation is somewhat better in Cres-Lošinj Archipelago in Croatia.

Primary activities had other secondary impacts. For example, oak forests were cultivated, as acorns were used extensively for leather tanning and as fodder for pigs. In many islands, the countryside was characterised by long stone walls, mainly for dividing grazing areas, stables, round wheat threshing platforms, watering troughs and fountains and other auxiliary structures. These elements organised landscapes and became an integral part of their cultural aspects.

Historical and political factors also played a significant role in the formation of the cultural landscape. For example, Cyprus, while under Venetian rule, was a wealthy island with vineyards, cotton plantations and fields of sugarcane, through forced labour of the local peasant population. In 1572, when the Turks occupied the island, all this cultivated land was abandoned as a reaction against the previous Venetian rule (Braudel 1966, p. 156).

5.3.3 Settlements and Edifices

For reasons of security mainly, many settlements were built in the interior of islands, at elevated positions, sometimes hidden from the sea, and constituted significant elements of cultural landscapes (Fig. 5.3). They were often twinned with much smaller settlements on the seashore, which were abandoned in case of attack. Other major coastal settlements were associated with places and periods in which marine power provided sufficient security. The fortified city of Valetta in Malta is a characteristic example, retaining its major cultural elements practically unchanged.

In the rural areas, the density of farms varied according to demographic and social factors, but was always in balance with the need to maintain cultivable land. Other major constructions were monasteries, wind mills and industrial facilities for the treatment of local products (such as wineries, oil mills and fish canning facilities).

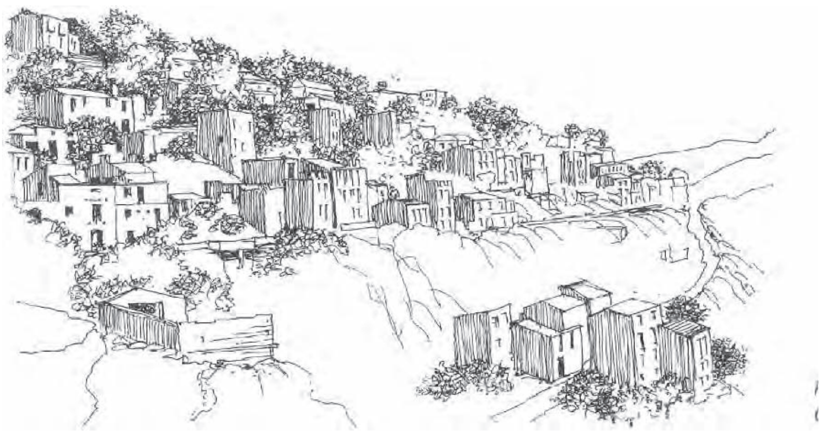

Fig. 5.3 The village of Old Gairo in Sardinia (Makhzoumi and Pungetti 1999. Reproduced with permission from Routledge)

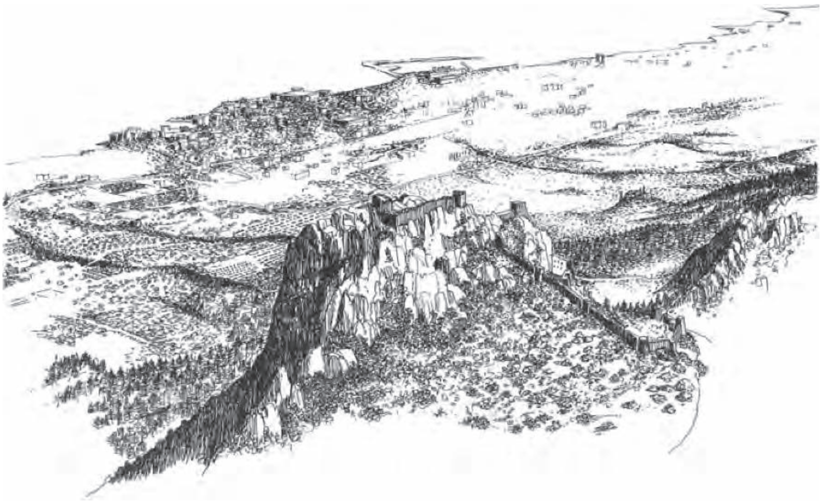

Fig. 5.4 A view from St Hillarion castle in the Kyrenia Range overlooking the coastal plain and the harbour town of Kyrenia (Girne) (Makhzoumi and Pungetti 1999. Reproduced with permission from Routledge)

5.3.4 Landmarks

Traditional landmarks include country churches, sometimes of unique architecture, many built by family clans. In some of the Aegean Islands, they number in the hundreds. They have been erected either on prominent places, or are modestly integrated in the landscape.

Castles are also important landmarks in the Mediterranean Island landscape (Fig. 5.4). Many of them date back to the Byzantine period when the first transition from *polis* to *castron* occurred. Also built in prominent places, their walls embraced the towns of the Mediterranean Islands. The modern *chora* of the Aegean Island is most of the times nothing else than the modern construction of a town built within or on top of the ruins of a Medieval, Venetian or Ottoman castle.

Lighthouses provide distinctive landmarks in coastal landscapes. In some islands, such as Tinos in the Cyclades, Greece, pigeon coops have been turned into strong visual elements because of their characteristic and highly decorative architecture.

5.3.5 Infrastructure

Due to technical limitations, road networks were traced along old footpaths, which followed the slopes of the land, and did not require extensive earth moving. Many of them were defined by stone retaining walls and were paved in stone, sometimes

Fig. 5.5 The Spinalonga (Kalidon) islet, in the Northeast of Crete in the Elounda bay. The islet is dominated by a Venetian fortress built on the ruins of an ancient acropolis. It has been used from 1903–1957 as one of the last active leper colonies in Europe (Photo courtesy of M. Maragakis) (*See Colour Plates*)

with consummate skill. They were well integrated in the landscapes and often constituted a significant cultural element, contributing to the organisation of space. In the case of the Maltese islands, the road network that was recovered implied something even more intriguing on the use of paths and roads even since prehistoric times. The network there did not just represent a communication system, but also a ceremonial and symbolic transport. At another level the remaining tracks may represent an exaggerated strategic response to a period of unusual stress associated with a catastrophic change in their main resources. The remains of the network then are a result of a strategy adopted in response to the environmental crisis that had occurred at the time (Hughes 1999).

Harbours in turn were modest in size and made use of protective coastal elements, following natural forms. Built and transformed under very slow processes, they were very effective in providing protection to shipping and contributed to the evolution of coastal cultural landscapes.

Fortresses were also a part of the security infrastructure of islands, especially during the Venetian period (Fig. 5.5); the Myrina fort in Lemnos Island – built in 1186 AD, is an example. Some of the fortifications were much older. Thus, in Sardinia, the Su Nuraxi di Barumini, large fortifications in the shape of truncated cones, date probably from the later part of the 2nd millennium BC. Today, these constitute a strong element of cultural landscapes.

5.3.6 Salinas

Salinas, that is, the entire installations for extracting salt from seawater (Petanidou et al. 2002) are found at the interface of land and sea, inextricably combining these two elements. Artisan salinas created their own characteristic cultural landscapes, with utilitarian constructions and infrastructure. In addition, they included important ecosystems and provided valuable (and usually protected) resting, feeding and nesting places for many species, and in particular waterfowl. This is exemplified by the saltworks of Ibiza and Formentera which contain a high number of endemic plants and many bird species (Chapter 12). They have become, however, uneconomical and unable to compete with industrial installations for salt extraction. Those that survive attempt to promote a quality luxury product and to capitalise on their cultural values. The rest are disappearing and are converted to aquaculture facilities and to land for urban and tourism development (Petanidou et al. 2002).

5.3.7 Archaeological Sites

Remnants of past civilisations, in the form of towns, sanctuaries or isolated buildings, are another major element in cultural landscapes, and Mediterranean Islands benefit from a great variety and quality of such remnants. From the Neolithic settlements of Aghia Irini in Kea and Polyochni and Myrina in Lemnos to the ancient Synagogue in Djerba, from the magnificent remains of the Athenian Alliance in Delos to the sombre monasteries of the Balearic Islands, the ages have left a great cultural wealth (Iacovou 2004). This wealth, viewed also as a tourist attraction potential, is supposed to be protected through the designation of protected archaeological zones, but is often exposed to destruction for reasons of ‘development’, while funds for its study, conservation and enhancement are scarce. In addition, their surrounding environment is usually uncontrolled and contemporary constructions are constantly approaching, threatening their unique role in the landscapes. In Greece, for example, the archaeological law provides for a control zone of 500 m around major archaeological sites. However, this is neither sufficient, nor rigorously applied.

5.3.8 Spiritual Aspects

In traditional societies, certain elements and areas of cultural landscapes were imbued with strong spiritual relevance. They included sacred places, such as sources, groves, mountain tops, as well as areas around religious buildings. In Antiquity, Delos Island in the Aegean was considered sacred and was protected from incompatible activities. The Patmos Monastery, carrying the legacy of St. John the Theologian and the Apocalypse, has conferred a sacred character to the entire island, at present severely contested (Dousis and Zervaki 1998).

Even today, religious and social events related to specific places – such as processions, special masses and panegyries – are common and are celebrated in most of the Mediterranean Islands, attracting both local inhabitants and visitors. A characteristic example is the Church of St. George on Prince Island in Turkey, which receives both

Christian and Moslem pilgrims. In Tinos Island, the Church of the Virgin has become a famous pilgrimage, especially around 15 August, with tens of thousands of visitors.

A particular case concerns sacred sites associated with natural areas of high biodiversity. The ancient Lluc Monastery in the heart of the Serra de Tramuntana mountain range in Mallorca, in Spain, where the *Verge de Lluc* is venerated, is such a case; efforts are being made to confer on this site a special protection status. In the *Parc National du Port-Cros* in France, the *Fort de la Repentance* – a characteristic example of the 19th century military architecture – has become a Christian Orthodox dependency of the famous Simonopetra Monastery in the Holy Mountain and contributes to local conservation efforts.

5.4 Contemporary Pressures on Cultural Landscapes

In our days, human impacts on Mediterranean Islands have changed in both qualitative and quantitative aspects. Many of the islands have experienced demographic losses, concerning their permanent inhabitants. On the other hand, most have been receiving seasonal inflows of visitors, necessitating extensive facilities and services. Thus, the island of Myconos in the Aegean, with 6,200 inhabitants (in 2002), can accommodate three times as many visitors at peak season. The Residential Units in 1991 were 23%, while the Tourist Units were 77% of the total accommodation units on the island. In 1960 it was 97% Residential and 3% Tourist (Coccossis and Parpairis 1996).

New patterns of land use have had profound impacts on land cover and even morphology (Cyffka 2003). Modern technology and resources have made feasible large-scale interventions, carried out in record times, which would have been impossible in the past centuries. Globalisation and ease of movement have made such interventions financially attractive. All of these factors – operating in a cumulative manner – are having a dramatic impact on island landscapes and on their cultural values (Green and Vos 2001).

5.4.1 Land Commercialisation and Expanding Urbanisation

Easier access to Mediterranean Islands by sea or air has fuelled the demand for resort housing. To some extent, this demand was initially covered by the transformation of existing houses in settlements or rural areas; it had a secondary beneficial impact as it led to the conservation of local architecture. As it increased, however, the cohabitation that resulted tended to undermine local social and family structures.

Soon, the supply of existing houses was exceeded and the demand shifted to larger and more luxurious properties, with broader grounds, swimming pools, garages and other facilities. The solution adopted was to urbanise rural and

Fig. 5.6 The broad and shallow ravines at Karakum (Karakumi) are utilised by industrial (left), commercial (centre) and residential buildings (Makhzoumi and Pungetti 1999. Reproduced with permission from Routledge)

natural areas, which was carried out promptly and with little previous planning. As a result, local farmers discovered rapidly that the land they had cultivated for generations with meagre results had attained now astronomical prices, which could satisfy their 'wilder dreams'. Many went ahead and sold their fields, piece by piece, not realising that they were disposing irrevocably the patrimony of their children and grandchildren. The changing conception of land from use to commodity has often been assisted by tax services and their valuation of properties based on their potential market values, which has provided a strong incentive for urbanisation.

The result of all these factors is a dramatic change of cultural landscapes from traditional/rural to suburban (Fig. 5.6).

5.4.2 Tourism and Resort Facilities

The demand for tourist facilities, initially covered by *rooms-to-let* within settlements, compounded the problem by requesting land –usually coastal – for their construction. Thus large parcels of land, either agricultural or natural, were transformed, built, fenced and landscaped with often alien, tropical species. The impact of such tourism facilities on cultural landscapes has been dramatic. In some islands, more than half of their coastal zone has by now become urbanised. In Hvar Island on the Dalmatian coast, public investment in the construction of large tourist facilities and the related infrastructure has not satisfied demand, which has led to a building boom of *rooms-to-let*, mostly illegal and beyond any public control. The result on landscapes has been dramatic.

Some tour operators have played a particularly negative role in this process. They have always been in search of unexploited islands, which might be attractive to their clientele. Once discovered, the tour operators provide encouragement to local property owners to build – usually substandard – facilities, which they rent at low prices. After a few years, they move to another location and the owners are left to fend on their own. In the meanwhile, the facilities built have debased entire segments of often pristine coastal zones. The case of the South of Corfu and Zakynthos Islands in Greece is characteristic.

5.4.3 Modern Infrastructures

Tourism activities have also secondary impacts. The need for improved access has led to the construction of airfields in even small islands. Often designed in an insensitive manner, their construction cutting through wetlands (as in the case of Corfu, Lemnos and Larnaca in Cyprus) or brutally levelling hills has scarred the landscapes of numerous islands.

For marine transport, harbours have been extended and new ones built. Designed by engineers, they have neglected completely environmental aspects and landscape integration. The extension of the harbour of the historic city of Rethymnon on Crete, in Greece is characteristic of the damage done. The requirements of marine tourism have led to the construction of large marinas in many islands, urbanising additional segments of their coastal zones.

Facilitating rapid automobile transport, but also serving isolated and distant tourist facilities, has led to the 'improvement' of island roads. To facilitate an increase in speeds, they have been straightened cutting through rock and backfilling, demolishing traditional structures, obliterating footpaths, thus causing extensive damage to cultural landscapes. Recently the Municipality of Santorini Island 'improved' one of the local roads and destroyed completely a unique volcanic rock formation, which was famous internationally.

Telecommunication needs have dotted many high points with an array of antennas. They are complemented in some cases by wind electricity generators, creating a new cultural landscape for modern times.

5.4.4 Excessive Water Demands and Their Impacts

The new non-permanent residents of islands, through their model of living and the facilities that serve them (such as swimming pools, tropical gardens and golf courses) are great consumers of water. Most islands had suffered always from lack of freshwater, as their water resources depended on precipitation, and had devised wise systems for the equitable management of the meagre water resources. This traditional balance has been totally upset by the new demands. The construction of small dams, as in the islands of Naxos and Tinos, has not resolved the problem. Excessive abstraction of water from aquifers has led at times to the salinisation of underground water and even its pollution by toxic natural chemicals. The water supply in the Greek islands of Egina and Kea, for example, has become so saline that people rely almost entirely on bottled water; that of the island of Chios, also in Greece, is reputed to be polluted from arsenic deposits, but there is no conclusive evidence as yet.

Desalinisation has given some positive results (as in the case of Myconos Island, and more intensively in Cyprus), but costs remain high. Even higher are the costs of transporting water from the mainland by pipe line or tankers, which is a last resort solution, widely applied.

Increased water scarcity has a serious impact on cultural landscapes, as it leads to their desiccation and gradual desertification. In Kea Island, for example, permanent streams that led from inland sources to the beaches have dried up within the past few years, and their rich flora and fauna have disappeared.

5.5 Positive Trends and Measures

One could go on describing the dramatic impacts of contemporary human activities on the fragile cultural landscapes of Mediterranean Islands. There are, however, a few encouraging trends that may create positive developments in the future.

5.5.1 The Beginning of Awareness

In a number of islands awareness of the growing problems from unregulated development is increasing. The main reason has been economic. The initial tourism boom is tapering off, mainly due to competition from cheaper and exotic destinations in other parts of the world. To counteract this threat, competitive advantages are sought, one of which is the natural and cultural wealth of Mediterranean Islands and the resulting cultural landscapes. For a different reason, this trend is being supported by outsiders who were attracted to the islands for their quality of life, have established primary or secondary residences, and have gradually discovered that this quality is degrading rapidly. As allies, they have some of the younger island inhabitants, who are faced with lack of property and employment, and have to compete for housing at international prices.

All of these social elements are generating pressure on decision-makers to take measures, which might have positive impacts on cultural landscapes.

Table 5.1 World Heritage Sites in Mediterranean Islands

Country	Site	Designation date
Cyprus	Paphos	1980
	Painted Churches in the Troodos Region	1985, 2001
	Choirokoitia	1998
France	Cape Girolota, Cape Porto, Scandola Nature Reserve and the Plana Calanches in Corsica	1983
Greece	Medieval City of Rhodes	1988
	Delos Island	1990
	Monastery of Nea Moni in Chios Island	1990
	Pythagoreion and Heraion of Samos Island	1992
	Historic Centre (Chora) with the Monastery of St. John and the Cave of the Apocalypse on the island of Patmos	1999
Italy	Portovenere, Cinque Terre and the islands of Palmaria, Tino and Tinetto, Liguria	1997
	Su Nuraxi di Barumini, Sardinia	1997
	Archaeological Area of Agrigento, Sicily	1997
	Villa Romana del Casale, Sicily	1997
	Isole Eolie (Aeolian Islands) in the Tyrrhenian Sea	2000
	Late baroque Towns of the Val di Noto, SE Sicily	2002
	Syracuse and the Rocky Necropolis of Pantalica	2005
Malta	Hal Saflieni Hypogeum	1980
	City of Valetta	1980
	Megalithic Temples, Gozo and Malta Islands	1980, 1992
Spain	Ibiza Island (biodiversity and culture)	1999

Table 5.2 Man and the biosphere sites in Mediterranean Islands

Country	Site	Designation date
Greece	Gorge of Samaria	1981
Italy	Tuscan Islands	2003
Spain	Minorca Island	1993
Tunisia	Zembra and Zembretta Islands	1977

5.5.2 International and National Efforts in Favour of Cultural Landscapes

Currently in few Mediterranean countries there are policies specifically addressing landscapes (Chapter 6). Slovenia is leading the way being the only Mediterranean country at present that has established a detailed inventory of its landscapes and has developed policies for their conservation and management (Marušič and Jančič 1998). Yet, this may change due to international developments. Thus, the World Heritage Convention has been designating sites of particular importance because of both their natural and cultural heritage (Table 5.1). Other sites have been designated in the framework of UNESCO's Man and the Biosphere Programme (Table 5.2). The entire island of Minorca, for example, has been declared a Biosphere Reserve by MaB (Borrini-Feyerabend et al. 2004). Most of the sites designated include important cultural landscapes that should be protected in principle; however in practice, designation has not proven an effective means of ensuring appropriate management. In addition, these two multilateral agreements must be made more aware of landscape aspects.

The European Landscape Convention in turn came into force only in March 2003. It has been ratified by a small number of Mediterranean countries, but it will help in cultivating interest in landscapes and its influence in the region will grow. The Ramsar Convention on Wetlands (signed in 1971) has included in its Resolution VIII.19 guidance on the protection of cultural landscapes in relation to wetlands and water and work is being carried out to develop it further and to implement it. Besides small island wetlands, the Convention includes coastal marine areas down to a depth of 6 m and, therefore, is of particular importance for islands.

All these international initiatives are still in early stages in relation to cultural landscapes, but their increasing influence on policy makers – mainly at the national level – should not be underestimated.

5.5.3 Implementing Sustainability: Approach and Tools

In a world guided today by financial concerns, cultural landscapes must be seen as resources that must be managed in rational ways, so that they can contribute benefits to human beings. This would be totally reasonable in the framework of implementing sustainability, a policy which has been broadly accepted as a common approach by the United Nations and the European Union, but is lacking in practical applications. In this context, the Mediterranean Committee on Sustainable Development has been debating issues related to sustainability in the region and may provide more specific guidance for islands.

Assistance can be also provided by the multiple efforts for sustainable tourism. Led by the tourism industry itself, but also adopted by the European Union, this movement intends to curb the negative impacts of tourism activities on sensitive destinations. One of its main issues is the conservation of the attraction potential of such destinations, of which cultural landscapes are a key element.

An integrated approach to the sustainable management of cultural landscapes must first recognise that they are not static, but necessarily evolve with time due to natural and anthropic factors, and also that landscapes cannot be viewed separately from the sustainable management of space and activities (especially land uses). For a specific island, such an approach might develop in the following steps:

- Identification of cultural landscapes on the island, using cartographic and photographic documentation and analysis of their specificities
- Inventory of natural and cultural elements that constitute the wealth of each landscape

- Functional analysis of the current human activities within each landscape unit and of their trends
- Identification of human pressures, current and predicted
- Prioritisation of landscapes in relation to their values and the imminence of threats
- Assessment of the carrying capacity of particularly sensitive areas (Papayannis 2004)
- Study of means to satisfy legitimate human needs, without degrading the values of cultural landscapes; appropriate use of Environmental or Strategic Impact Assessments to evaluate major projects

The draft management plan for the conservation of the Cres-Lošinj Archipelago in Croatia, currently in preparation, uses a similar methodology, with inclusive objectives in the framework of sustainability, includes a strong participatory element, and takes into account landscape aspects (Randić 2004). In Minorca, the local governing body (*Consell Insular*) has launched since 1997 a process for the preparation and approval of a Plan for Sustainable Development, with the active contribution of most stakeholders (Borrini-Feyerabend et al. 2004). When implemented, it will have a decisive influence on the cultural landscapes of the island. Perhaps the greatest difficulty in carrying out such comprehensive approaches to cultural landscapes is the sectoral nature of most public services, which have competence for separate facets, but not for the whole. Perhaps planning services can develop the capacity to view space in an integrated manner, taking into account social, ecological and cultural aspects.

5.5.4 Scenarios for the Future

If current trends continue, it is certain that Mediterranean Islands will go through a phase of intense urbanisation, at the loss of both the natural environment and cultural landscapes. The result will be a dramatic drop in the quality of life and the attraction potential, which will lead eventually to economic stagnation, unemployment and emigration. Recovery will not be possible, at least in a horizon of a few generations. A more positive scenario would entail the establishment of a sustainability plan for each island, especially those that have not been already excessively developed. After extensive dialogue with all stakeholders, the plan would be implemented in gradual steps, taking fully into account the need to adjust equitably expected longer-term benefits with short-term losses. The main objectives would be the diversification of economic activities and the increase of employment opportunities, the conservation of the natural and cultural heritage, the improvement of the quality of life and of services.

All this may sound as overly optimistic, but there are some positive developments. In Minorca, by official zoning, a considerable part of the coastal zone has been placed beyond urbanisation. In Mallorca, a few outdated hotels on the seashore, erected in the 1960s, were recently demolished to improve the environment.

In such a positive context, cultural landscapes would be viewed as highly valuable assets. Only then would the present and future generations be able to imbue landscapes with their own culture.

References

Atkins, P., Roberts, B. and Smith, I. (1998) People, Land and Time, Hodder and Stoughton Educational. London.

Binford, L.R. (1978) Dimensional analysis of behaviour and site structure: learning from an Eskimo hunting stand. American Antiquity 43: 330–361.

Borrini-Feyerabend, G., Larrucea, J.R. and Synge, H. (2004) Participatory management in the Minorca Biosphere Reserve, Spain. In H. Synge (ed.) European Models of Good Practice in Protected Areas. IUCN: Gland, Switzerland and Cambridge; The Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management, Vienna, pp. 16–24.

Braudel, F. (1966) The Mediterranean and the Mediterranean World in the Age of Philip II. Collins: London, Vol. I.

Broodbank, C. (2000) An Island Archaeology of the Early Cyclades Cambridge University Press: Cambridge.

Chapman, J., Shields, R. and Batović, S. (1996) The changing face of Dalmatia: archaeological and ecological studies in a Mediterranean landscape. Reports of the Research Committee of the Society of Antiquaries of London, p. 54.

Cherry, J.F. (1985) Islands out of the stream: isolation and interaction in early east Mediterranean insular prehistory In A.B. Knapp and T. Stech (eds.), Prehistoric Production and Exchange: The Aegean and Eastern Mediterranean (UCLA Institute of Archaeology Monoraph 25). UCLA Institute of Archaeology: Los Angeles, CA, pp. 12–19.

Cherry, J.F (1990) The first colonisation of the Mediterranean Islands: a review of recent research. Journal of Mediterranean Archaeology 3, pp. 145–221.

Cherry, J.F. (ed.) (1995) Colonisation of islands. World Archaeology 26. Routledge: London.

Coccossis, H. and Parpairis, A. (1996) Tourism and carrying capacity in coastal areas: Mykonos, Greece', in G.K. Priestley, J.A. Edwards and H. Coccossis (eds.) Sustainable Tourism? European Experiences, CAB International: Oxon, UK, pp. 153–175.

Cyffka, B. (2003) Land Cover Changes by Land Use Changes on Mediterranean Islands' Workshop on Global and Land Use/Cover Changes, 17020 July 2003, Moscow, Russia.

Davis, S.J.M. (1987) The Archaeology of Animals. Batsford: London, pp. 118–125.

Diamond, J. (1998) Guns, Germs and Steel, Vintage. Random House: London.

Dousis, E. and Zervaki, A. (1998) Islands as cultural landscapes: the case of Patmos. International Journal of Island Affairs 4.

Evans, J.D. (1977) Island archaeology in the Mediterranean: problems and opportunities. World Archaeology 9(1), 12–26.

Faulkner, H. and Hill, A. (1997) Forests, soils and the threat of desertification. In R. King, L. Proudfoot and B. Smith (eds.) The Mediterranean; Environment and Society. Arnold: New York, pp. 252–272.

Gamble, C.S. (1979) Surplus and self-sufficiency in the Cycladic subsistence economy. In J.L. Davis and J.F Cherry (eds.) Papers in Cycladic Prehistory (UCLA Institute of Archaeology Monograph 14) UCLA Institute of Archaeology: Los Angeles, CA, pp. 122–134.

Green, B. and Vos, W. (eds.) (2001) Threatened Landscapes: Concerning Cultural Environments. Spon Press: London.

Head, L. (2000) Cultural Landscapes and Environmental Change. Hodder & Stoughton Educational: London.

Hodder, I. (ed.) (1978) The Spatial Organisation of Culture. University of Pittsburgh Press: Pittsburgh, PA.

Hughes, K.J. (1999) Persistent features from a paleo-landscape: the ancient tracks of the Maltese Islands. The Geographical Journal 165(1), 62–78.

Iacovou, M. (ed.) (2004) Archaeological Field Survey in Cyprus: Past History, Future Potential. The British School at Athens, Studies II: Nottingham, UK.

Ioannides, D. (2002) Tourism Development in Mediterranean Islands: Opportunities and Constraints. In Y. Apostolopoulos and D.J. Gayle (eds.) Island Tourism and Sustainable

Development; Caribbean, Pacific, and Mediterranean Experiences. Praeger: London, pp. 67–92.

Jones, M. (2003) The concept of cultural landscape: discourse and narratives. In H. Palang, and G. Fry (eds.) Landscape Interfaces: Cultural Heritage in Changing Landscapes. Kluwer: Dordrecht, pp. 20–51.

Loukissas, P. and Triantafyllopoulos, N. (2002) Island-community involvement in tourism land-use planning. In Y. Apostolopoulos and D.J. Gayle (eds.) Island Tourism and Sustainable Development; Caribbean, Pacific, and Mediterranean Experiences. Praeger: London, pp. 249–272.

Marušič, J. and Jančič, M. (1998). Regional Distribution of Landscape Types in Slovenia: Methodological Bases. Ministry of Environment and Physical Planning: Ljubljana.

Matvejević, P. (1990) Mediterranean: A cultural landscape. University of California Press: Berkeley and Los Angeles, CA.

Naveh, Z. (1995) Interactions of landscapes and cultures. Landscape and Urban Planning 32: 43–54.

Naveh, Z. (1990) Landscape ecology as a bridge between bio-ecology and human ecology. In: H. Svobodova (ed.) Cultural Aspects of Landscape. Pudoc: Wageningen: 45–58.

Naveh, Z. (1998a) Culture and landscape conservation: a landscape-ecological perspective. In: B.P Gopal, P. Pathak and K.G. Saxena (eds.) Ecology Today an Anthology of Contemporary Ecological Research.. International Scientific Publications: New Delhi, pp.19–48.

Naveh, Z. (1998b) From biodiversity to ecodiversity – holistic conservation of biological and cultural diversity of Mediterranean landscapes. In: G. Montenegro, F. Jaksic and P.W. Rundel (eds.) Landscape Disturbance and Biodiversity in Mediterranean-type Ecosystems. Ecological Studies 136, Springer: Berlin Heidelberg, pp. 23–54.

Papayannis, T. (2004) Tourism carrying capacity in areas of ecological importance. In H. Coccossis and A. Mexa (eds.) The Challenge of Tourism Carrying Capacity Assessment. Ashgate: Aldershot, UK, pp. 151–162.

Petanidou, T., Dahm, H. and Vayanni, E. (eds.) (2002) Salt and salinas as natural resources and alternative poles for local development. Proceedings of the ALAS Final Conference, University of the Aegean, Mytilene, Greece.

Phillips, A. (2002) Management Guidelines for IUCN Category V Protected Areas: Protected Landscapes/Seascapes. IUCN: Gland, Switzerland and Cambridge.

Posey, D.A. (1999) Cultural and Spiritual Values of Biodiversity. UNEP – Intermediate Technology Publications: London.

Randić, A. (2004) Environment Management Plan for the Cres-Lošinj Archipelago (www.insula.org/Croatia).

Renden, H. (1997) Earth surface processes in the Mediterranean. In R. King, L. Proudfoot and B. Smith (eds.) The Mediterranean; Environment and Society. Arnold: New York, pp. 46–56.

Richards, P. and Robertson, I. (2003) Studying Cultural Landscapes. Hodder & Stoughton Educational: London.

Said, E.W. (1994) Culture and Imperialism. Vintage: London. pp. 1–7.

Van Mansvelt, J.F. and Van der Lubbe, M.J. (1999) Checklist for Sustainable Landscape Management. Elsevier: Amsterdam.

Viñals, M.J. (ed.) (2002) El patrimonio cultural de los humedales/Wetland cultural heritage, Ministerio de Medio Ambiente, Valencia, Spain.

Zedeño, M.N. (2000) On what people make of places; a behavioural cartography. In M.B. Schiffer (ed.) Social Theory in Archaeology. University of Utah Press, pp. 97–111.

Chapter 6
Political Landscapes of Mediterranean Islands

I.N.Vogiatzakis[1], Th. Papayannis[2], and A.M. Mannion[3]

All islands are part of the European Union

6.1 Introduction

What is meant by political landscapes?
All landscapes, because they have been moulded by human action, are to some extent political. This is particularly evident in the Mediterranean Basin, a crossroad where civilisations have coalesced and often clashed. Although the larger of the

[1] Centre for Agri-Environmental Research, University of Reading, UK

[2] Mediterranean Institute for Nature and Anthropos (Med-INA), Greece

[3] Department of Geography, University of Reading, UK

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Mediterranean Islands have been the home centres of great civilisations (Chapters 3 and 5) during prehistoric times, they have been unable to resist the repeated invasions of mainland-based powers that battled successively for political and commercial authority. The strategic location of the islands meant that they were ideal for defence, trade and exploitation of natural resources and therefore an attraction to outsiders. The Mediterranean Islands discussed herein have been used as temporary and/or permanent bases of world powers, a practice that continues today given that the USA and the UK still retain military bases there. For most of their histories the larger Mediterranean Islands have been in a position of political subservience to an outside power. Some remain powerless in political terms because they have little autonomy from mainland governments (Royle 2001).

During the course of history Mediterranean Islands have changed hands among emerging powers or as a result of conflicts and subsequent international treaties. All of the islands discussed in this book fought for independence with two, Malta and Cyprus, gaining independence from Britain as recently as the 1960s. Following independence, the majority of islands became part of their respective mainlands (Table 6.1). For some of the islands, notably Crete, Sardinia and Sicily joining the motherland has been a voluntary act, while for others unification was imposed by armed conflict as in the case of the Balearics and Corsica. Island exchange has continued to take place even during the last 100 years. For example, Greece lost the islands of Imvros and Tenedos islands to Turkey (in Turkish these are the Gökçeada and Bozcaada islands) following the Lausanne treaty in 1923 while the Dodecanese islands joined the Greek state after secession from Italy in 1947. Cyprus was the battlefield of armed conflict in 1974 which left the island divided in two parts: northern Cyprus is under Turkish control while southern Cyprus is an independent state recognised by the UN. The islands of the Dalmatian coast following World War II and the disintegration of the former Yugoslavia in the early 1990s are now part of Croatia.

During the last century the limiting resources of the islands in conjunction with geopolitical events (mostly conflicts) have led to a variety of demographical patterns. Generations of islanders responded to the problems of peripherality/isolation

Table 6.1 Important dates in the islands' recent political history

	Period as Independent State	Year of Independence or Joined Mainland	Accession year to the European Union
Sicily		1860	1958*
Sardinia	1848–1860	1861	1958*
Cyprus		1960	2004**
Corsica	1755–1769	1769	1958*
Crete	1898–1913	1913	1981
Balearics	1276–1344 (Mallorca) 1287–1344 (Minorca)	1802	1986
Malta		1964	2004

*The French and Italian islands effectively entered the then called European Economic Community. **Applies only to the southern part of the island under the UN-recognised Republic of Cyprus.

(Chapter 1, Table 1.3) by migrating. Sicilians left en masse to the USA between 1900 and 1914, with Kalymnians going to Australia, and Sardinians to Germany and France. Different scale migrations occur even today; islanders migrate to the mainland or internally from the mountainous interiors to the large coastal cities, while in archipelagos the larger islands draw people from the smaller islands. In very few cases have the islands received migrants from other places. Examples include the larger Greek islands which received Greek migrants from Asia Minor after the 1922 conflict with Turkey and Corsica (see Chapter 9) which received French expatriates and their personnel following the French decolonisation of northern Africa in the early 1960s. Many Mediterranean Islands have been sufficiently close to the African coast to have been the stepping stones for illegal immigrants to Europe in the last decade.

The way by which Mediterranean Islands are administered by their mainland governors varies, depending on country, often reflecting island size, resources and population. Mediterranean Islands which are parts of a country are affiliated to many different organisational and political frameworks. Nevertheless, the majority are predominantly under the economic and political influence of the European Union (EU). The political and administrative relations of the Mediterranean Islands with each other and with their respective states and the EU are complicated. All these cultural, geopolitical and administrative layers, both historical and recent, have shaped their distinct landscapes. This chapter reviews the recent historical and political factors and processes that have shaped Mediterranean Island landscapes and examines the place of 'landscape' as a reflection of cultural, ecological and economic factors in the political agenda.

6.2 Islands, Resources and Administration

The administration of islands is problematic and challenging for the administrators, usually the mainland state, and the islanders themselves. Worldwide islands are economically, socially and physically vulnerable by their very nature. Land area and often water, are the main limiting factors which affect the islands' capacity to provide the goods and services to meet domestic needs and thus the islands become dependent on imports. The social, economic, administrative and political fabric of the Mediterranean Islands is as diverse as the islands themselves. Industrial development is limited in the islands the majority of which rely on tourism to generate income which, in turn, balances this demand for imported goods and services (Morey and Martinez-Taberner 2000). Tourism which was encouraged particularly in the 1960s and 1970s has transformed island landscapes and brought new pressures which have caused environmental change. The kind of tourism developed in the majority of the Mediterranean Islands is 'product-led' which means that, economic growth through the development of new and maintenance of existing products prevails over environmental issues (Kousis 2001). Thus not all political decisions are directly related to the environment but still have an environmental impact. Space constraints have an effect not just on agricultural production but also on housing, infrastructure, waste disposal, and industrial development. Groups of islands in the Mediterranean (archipelagos) are usually faced with double insularity. This concept involves the difficulties imposed by a small population spread out over a number of small islands (EURISLES 2002). In addition islands, particularly the smaller ones, are at risk from many environmental hazards, such as earthquakes, coastal-, river- and rain-induced flooding. The region in which the Ionian Islands (north-west Greece) lie is the most seismically active area in the whole of western Eurasia (i.e. from Gibraltar to China) while Crete is situated where the African and the European tectonic plates collide. Sicily is home to Etna with Stromboli off its north-eastern coast; these are two of the most active volcanoes in the world.

Although the presence of resources on islands is constrained by their physical setting the use of these resources is influenced mainly by political decision-making. A major problem is that island scale (i.e. the unit of resource production) may coincide with three different administrative levels (Fig. 6.1) and therefore is a heterogeneous unit shaped by varying weight of political influence and decision-making. Consequently, while physical constraints might impose similar resource restrictions on the majority of the Mediterranean Islands the extent, ability and effectiveness to which islanders are managing their resources depends on the status of their island.

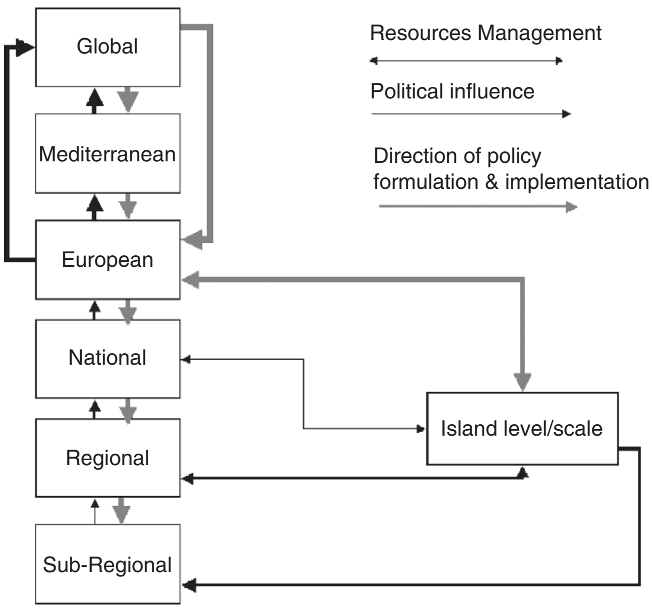

Fig. 6.1 The levels of policy formulation, administration and resource management in the Mediterranean Islands. The thickness of the arrow indicates the strength of the link

Decision-making occurs at regional level for most countries with islands, and most of the islands in the Mediterranean are off-shore parts of a mainland state. Therefore they fall below the regional administrative level with little or no political influence in national capitals or Brussels, the EU power centre. The same applies to policy formulation with islands being distant from this process, unless they are island states. Policy formulation usually takes place at the National and European level and is inevitably influenced by events on a larger geopolitical scale such as regional, e.g. Mediterranean or global. This is sometimes considered a unidirectional process (Fig. 6.1). For the island states, i.e. Malta and Cyprus, there is a distinct advantage over other Mediterranean Islands since they are members of the UN Small island Developing States Initiative. Therefore they can benefit, financially and through the exchange of information and best practices while at the same time have their voices heard on a range of issues (Hopkins 2002). Another organisation that comprises EU islands is the Conference of Peripheral Maritime Regions (C. P.M.R.) an independent body set-up to tackle the disadvantages of EU's periphery. Within this organisation the Island Commission is working specifically on EU-islands related issues (EURISLES 2002).

Some of the Mediterranean countries have in place special measures for their islands within the national government and central administration (Table 6.2). For example, Greece has a ministry for the Aegean and has established three island regions: northern Aegean (7 islands), southern Aegean (50 inhabited islands), Ionian (13 islands) while Crete is a separate administrative region. Currently it seems that France is the only country within Europe with no representation for small islands or special status for Corsica which continues to be a controversial issue.

It has been argued that past policies of negligence in combination with the belief by many islanders in their special origin and character have resulted in frequent clashes between the mainland and its offshore islands. For example, Cretans have a long and proud tradition of resistance to regulations imposed from outside the island (such as interdiction of firearms), while the foundation of the *Cosa Nostra* in Sicily has been partly attributed to local mistrust for the central, usually north

Table 6.2 Level of autonomy in the Mediterranean Islands of the European Union (From Hache 2000)

Islands	Autonomy granted by the National Constitution	Legislation power	Administration power	Common law
Sicily	√	√	√	
Sardinia	√	√	√	
Corsica			√	
Crete				√
Balearics	√	√	√	
North Aegean islands				√
South Aegean Islands				√
Ionian Islands				√

Italian dominated, administration. Sardinia and Corsica have also been home to notorious bandits.

6.3 European Union and the Islands

In the last 50 years with the establishment of the European Community (now the European Union) the political and administrative framework of Europe's member states has changed significantly. The place of islands has also changed from being just a part of a Nation State, into being the strategic fringes of continental Europe. As a result policies for the majority of economic sectors such as agriculture, transport, energy but also environment are now dictated by the EU. The extent to which islands have been able to influence the negotiations of adhesion by their Member State was partly dependent on the level, if any, of their autonomy status.

Entry to the EU (Table 6.1) marked many changes on the islands (Fig. 6.2). These changes are still a source of controversy amongst politicians and environmentalists. Agriculture, the major pressure in the islands, is now manipulated via the European Union's (EU) Common Agricultural Policy (CAP). EU subsidies have been responsible for the transformation of landscapes in many islands. They have intensified agricultural development to the point of overproduction while in some islands they have been diverted towards other inappropriate, sometimes conflicting and sometimes even damaging activities (Chapter 11). Traditional

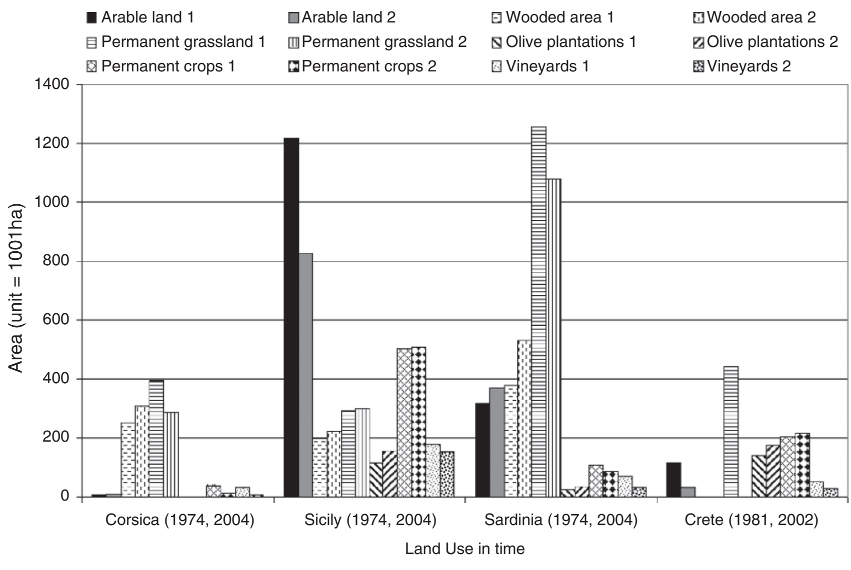

Fig. 6.2 Land-use changes in four Mediterranean Islands following entry to the European Union (From EUROSTAT 2006)

agricultural activities have declined or ceased in many islands (Chapter 8) while intensive agriculture has continued where investments in irrigation were made, as in Sicily, Sardinia and Crete. As the most recent entries, Malta and Cyprus will have to adjust their national agricultural policy to match the CAP.

The majority of island members have so far benefited from specific EU incentives, laws, tax arrangements or structures, be it at regional or national level. In recognition of island 'poverty' compared to the EU average, due mainly to their marginalisation, islands were placed under the categories Objectives 1 and 2 which denote the highest priority category for receiving EU structural funds. These include programmes such as INTERREG for promoting transnational co-operation on spatial planning, LEADER, which finances projects for rural development, and others (European Commission 2006).

The Treaty of Amsterdam (European Union 1997) introduced a number of important provisions to the EC treaty relating to islands:

- Article 158 mentions reducing the backwardness of least-favoured island regions.
- Declaration No. 30 defines the EU obligations in respect of island regions.
- Article 299 (2) requires the EC council to adopt specific measures for areas with special constraints such as insularity.
- Article 154 deals with trans-European networks between islands and central regions of the Community.

Despite what might seem a favourable legislative framework at the European level, critics of EU policies suggest that in many cases these special benefits are given also to any continental area that meets the necessary economic criteria/thresholds and that insularity has not been accounted for in these measures (EURISLES 2002). As a result EU policy fails to accept the islands' special conditions and adapt its policies accordingly or what a recent IUCN report refers to as the phenomenon of 'northern sunshades' (Hopkins 2002). The majority of consumers of Mediterranean Island summers are from northern Europe and include people who lead and shape EU environmental policies. Despite this, they appear reluctant to support islands and their problems in EU fora. For example, an extremely important issue – is that the EU does not recognise sufficiently the need to connect the islands with the mainland, through subsidised marine or aviation transport networks, in the name of free-market economy and competition. Moreover, the recent EU enlargement and any future enlargement plans, mean that the EU will be even more continental in nature. Thus there is cause for concern that islands will be neglected politically and financially as attention is turned to the new member countries.

Another issue emerging in the last decade as central to island policy is human immigration, that is, islands acting as stepping-stones to human movement from other continents, mainly Africa and Asia, into Europe. This is acute in the case of the Canaries, a European but not Mediterranean archipelago, but is also demonstrated by the cases of Malta and Lampedusa sparking the political debate about immigration and the borders of the EU. At the centre of this debate the Mediterranean Islands will inevitably be the protagonists demanding increased attention by the European mainland and its power centre.

6.4 Islands, Landscapes and Biodiversity

6.4.1 How Important is Landscape on the Political Agenda?

The development of protected landscapes by IUCN since the early 1970s recognised that effective conservation could not be achieved by focusing on traditional eco-centric approaches alone and that it was necessary to involve humans and cultural landscapes. The UNESCO (1972) convention on World Natural and Cultural Heritage was the first major initiative to place cultural landscapes on the worldwide political agenda. However, cultural landscapes were inscribed in the World Heritage List much later in 1993; this included a number of sites designated in the Mediterranean Islands (Chapter 5). Although protected landscapes/seascapes belong to IUCN Category V in the Mediterranean there are many different names used to denote a protected landscape/seascape (IUCN 1994a). Protected landscapes are advocated as an effective way of achieving holistic conservation and sustainable rural development. The definition of a Protected Landscape/Seascape, that is, a protected area managed mainly for landscape/seascape conservation and recreation is:

> *Area of land, with coast and sea as appropriate, where the interaction of people and nature over time has produced an area of distinct character with significant aesthetic, ecological and/or cultural value, and often with high biological diversity. Safeguarding the integrity of this traditional interaction is vital to the protection, maintenance and evolution of such area.*

The Mediterranean Landscape Charter (also known as the Sevilla Charter) was the first document to cover specific issues on the management and protection of the Mediterranean landscape (1993) and to stress the need for protection of the natural and cultural landscapes of the area as a whole. This was followed by the IUCN publication Parks for Life: Actions for Protected Areas in Europe (IUCN 1994b) which advocates an international convention on rural landscape protection in Europe, involving the Council of Europe. The European Landscape Convention was the first international charter aimed at ensuring improved management of Europe’s landscapes (Council of Europe 2000).

> *Landscape must become a mainstream political concern, since it plays an important role in the well-being of Europeans who are no longer prepared to tolerate the alteration of their surroundings by technical and economic developments in which they have had no say. Landscape is the concern of all and lends itself to democratic treatment, particularly at local and regional level (European Landscape Convention)*

The Pan-European Biological and Landscape Diversity Strategy (PEBLDS) was the first approach to address all biological and landscape initiatives under one European approach. This meant that the conservation of landscapes would be incorporated in the major initiatives dealing with biodiversity and that biological and landscape diversity would be integrated adequately into all social and economic sectors (Council of Europe/UNEP and ECNC 1996). At the national level there is a variety of legislation that indirectly affects island landscapes including legislation on historic monuments, protection of the environment and land use and planning.

However, national landscape initiatives in Europe are relatively new and many have not been implemented (Wascher 2001) although this is bound to change due to PEBLDS and the European Landscape Convention. However, because implementation takes place at the national and/or regional level the true effects of these conventions might still be several years into the future.

The shift in ecological thought on the influences of landscape processes on biodiversity (Forman and Godron 1986) was followed by the notion that landscape scale approaches are also fundamental to the understanding of past and present cultural processes (Aalen 2001). The landscape scale is now considered to be the appropriate spatial framework for the analysis of sustainability. Despite attempts at landscape classification at the European level (Meeus 1995; Wascher and Jongman 2003) and its wide use in north-west Europe as a tool for landscape planning, the development of a landscape typology for Mediterranean countries has been limited. Exceptions include Portugal (Pinto-Correia et al. 2002), Spain (Mata Olmo and Sanz Herráiz 2003) and Slovenia (Marušič and Jančič 1998). Certainly the Slovenian typology is more complete than others since it incorporates cultural landscapes. Such approaches are now advocated by international and national organisations to summarise pressures and threats and to develop policies for sustainability (Hopkins 2002). For example, Integrated Coastal Management is one of the approaches to the planning and management of coastal resources which attempts to overcome previous sectoral approaches and tackle development and conservation in a holistic manner (Cassar 2001). Such plans have been formulated in a few Mediterranean Islands by UNEP (UNEP 1994a, b, c). At the same time UNEP is evaluating landscape character assessment and its potential for coastal zone management (Vogiatzakis et al. 2005).

6.4.2 Biodiversity Protection

The importance of Mediterranean Islands' biodiversity (reviewed in Chapter 4) at a global level, points to the need for an extensive network of protected areas to safeguard vulnerable species and habitats. The number and extent of protected areas in the Mediterranean countries are very diverse (Vogiatzakis et al. 2006) something that reflects at the regional level upon the designations on islands of the area. Information on the extent and distribution of protected areas in the Mediterranean Islands is arduous to find since none of the existing databases can pull out islands as separate entities (Hopkins 2002). This would be a useful conservation tool, especially as islands generally are more vulnerable to environmental change than the mainland. As is the case for other sectors (Section 6.3) for most of the Mediterranean Islands EU policies are those which shape Biodiversity and Landscape Protection particularly in the last 20 years although there have also been other wider geographical initiatives (Table 6.3). It must be noted, however, that in the majority of these initiatives islands (other than island states) are not treated separately from their mainland state.

Table 6.3 Summary of the main policy and legislation instruments in the Mediterranean Basin

Instrument	Year	Scale	Focus
Mediterranean Action Plan (MAP)	1975	Mediterranean	Marine environment
Barcelona Convention	1976	Mediterranean	Marine environment
Nicosia Charter	1990	Euro-Mediterranean	Sustainable development
Sevilla Charter	1993	Mediterranean	Landscape
Alghero Convention	1995	Mediterranean	Coastal and marine biodiversity
Mediterranean Wetlands Strategy	1996	Mediterranean	Wetlands
Natura 2000 network	1992	European Union	Species and habitats
European Landscape Convention	2000	Pan-European	Landscape
PEBLDS (Pan-European Biodiversity and Landscape Strategy)	1996	Pan-European	Landscape, biodiversity
Convention on Biological Diversity	1992	Global	Biodiversity
UNESCO declaration on cultural diversity	2001	Global	Cultural diversity
UNESCO World Heritage Convention	1972	Global	Cultural heritage and Cultural landscapes

In the last three decades in Europe there has been a proliferation in the number of protected areas. This is due to the widespread interest in conservation, increased public awareness and in some cases the result of a new legislative framework, e.g. European Natura 2000 or in Spain after the establishment of the Autonomous Communities. The designation of Natura 2000 network is particularly important. Its development is illustrated in Figure 6.3 which shows that it has relatively long-term formulation to implementation time frame. In 1995 individual states recommended SCIs on the basis of existing knowledge although full time management will not be in place until after 2010. Prior to Natura 2000 some islands had already a good network of protected areas in place such as Sardinia, Corsica and the Balearics. Corsica (Chapter 10) and the Balearics (Chapter 12) are a special case since c.40% of the islands' territory is under some form of protection. For those islands, the Natura 2000 network will enforce what is already in place while for other islands such as Crete the number of protected areas will increase significantly following Natura 2000 designations. Sicily despite its size and considerable biodiversity (Chapter 7) has very few protected areas, either in the Natura 2000 network or more generally (Hopkins 2002). A past trend regarding protected sites was their designation on mountains far from areas of conflict with tourist or agricultural activities. This is bound to change with Natura 2000 network since many sites as exemplified by the cases of Sardinia (Chapter 8) and Crete (Chapter 10) are located along the coastal zone.

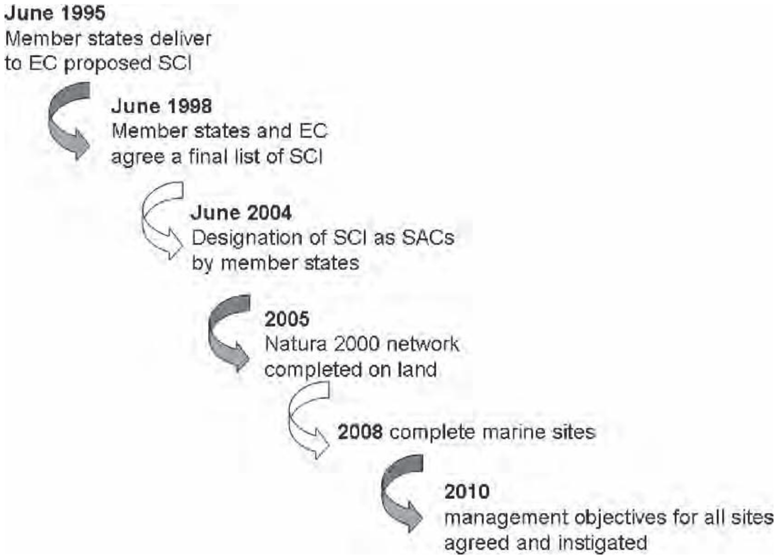

Fig. 6.3 The road map to biodiversity conservation in the European Union (Duke 2005)

Although any differences in the extent and size of protected areas between islands reflect the islands' characteristics (see Chapter 4), it is also clear that there are different attitudes regarding conservation approaches and their implementation by individual countries. For example, Italy and France have been condemned in the past by the EU Court of Justice for failing to designate all their most suitable territories as SPAs. Moreover, significant information gaps for Spanish SPAs remain (European Commission 2003). Another common problem for landscape and nature conservation in the Mediterranean as pointed out by individual researchers and international organisations alike is the lack of legislation or the ineffective enforcement of existing legislation (Delanoë et al. 1996; Vogiatzakis et al. 2006). Stakeholder participation in protected area management varies considerable from one country to another (see Papageorgiou and Vogiatzakis 2006). This is reflecting partly local attitudes towards conservation but also existing legislation.

The effects of the wider countryside are recognised in the Habitats Directive. Nevertheless the EU Natura 2000 network of protected areas is based on species and habitats (Council of Europe 1979, 1992) rather than landscapes. The designation of the Natura 2000 network of protected sites has sparked a debate all over Europe (WWF 1999; Hiedanpää 2002) regarding its adequacy and effective site selection but also regarding the criteria used for selection. One problem with the Natura 2000 designations, and one which is not specific just to islands, is the overlap with existing designations prior to Natura 2000 (Papageorgiou and Vogiatzakis 2006). To date, there has not been an assessment of the adequacy of the network for islands or Europe.

One of the recent controversial but potentially effective pieces of legislation at the European level which will also strengthen the protection of island environments is the Environmental Liability Directive. Adopted on 21 April 2004 the directive should be incorporated into national legislation by 30 April 2007 (European Union 2004). The underlying principle is to ensure that operators (potential polluters) give appropriate priority to avoiding environmental damage that can result from their activities, by holding them financially liable for damage prevention and remediation costs. It covers environmental damage to:

- Species and natural habitats, whether protected at EU or national levels
- Waters covered by the Water Framework Directive
- Land contamination, which creates a significant risk of harming human health

Their physical setting renders small islands highly sensitive to external shocks and highly vulnerable to natural disasters and therefore climate change. The IPCC report (2001) states that islands will be affected disproportionately by climate change since they contribute very little compared to mainlands. Mediterranean countries and particularly their islands face pressing socio-economic concerns (e.g. poverty, unemployment, health and education) which might be exacerbated by climate change. Consequently climate change receives lower priority in the national political agenda. Nevertheless, the majority of the Mediterranean countries have signed and ratified the Kyoto Protocol with the exception of Libya, Turkey, Lebanon, Yugoslavia and Bosnia Herzegovina who have no position on the document while ratification is pending for Croatia (UNFCC 2006).

6.5 Conclusions

Despite the similarities in their resource base and character, the Mediterranean Islands are heterogeneous politically. Malta and Cyprus are nation states while the other islands discussed are controlled politically by mainland states. Nevertheless the political landscape is nowadays dominated by the relationship between islands and the EU. This relationship is dynamic and constantly evolving. In the island states there is one less tier of administration. This is also demonstrated by the political status of EU island territories further a field, such as Guadeloupe, which despite the similarities with the Mediterranean Islands have chosen in the past different arrangements with the EU (CPRM 2000).

The most important environmental issues relevant to islands as identified by the Small Island Developing States Network of the UN are: biodiversity loss, climate change, coastal and marine resources, renewable energy, sustainable tourism, trade. Most of these themes are relevant to Mediterranean Island landscapes and are recurrent in the individual island chapters (7–13) in this book. However, resolving the problems of islands cannot rely on the intervention of the EU alone though it is beyond any doubt that these problems are influenced directly or indirectly by EU policies and some of those problems have arisen as

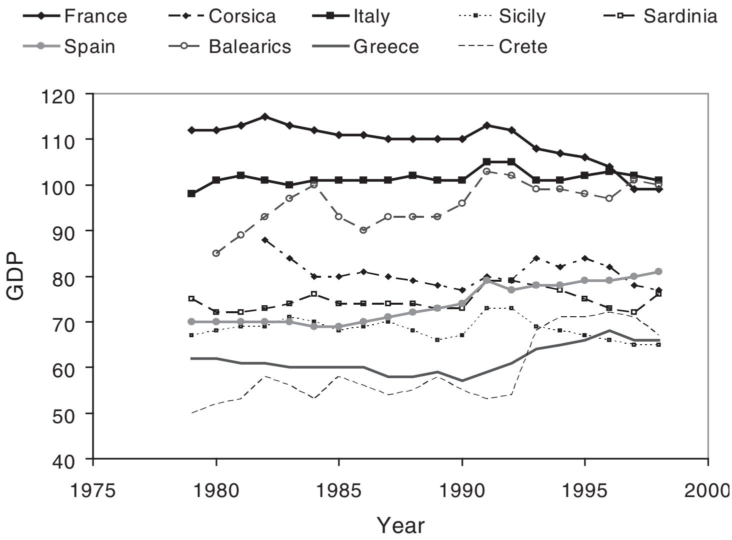

Fig. 6.4 A comparison of GDP between islands and their mainlands (From EUROSTAT 2006)

a result of those policies. The challenge is to formulate and implement policies that reconcile island particularities with free-market economy and competition. The great diversity of the islands in terms of socio-economic characteristics has been the main argument against a uniform islands EU policy. So far this has been measured simply by comparing the islands' unemployment rates and GDP per head with the EU average (Fig.6.4). However a report by EURISLES (2002) advocates the use of evaluation parameters to provide a more accurate reflection of the capacity or otherwise of the islands to benefit from EU policies. These parameters may include degree of accessibility, extent of the natural or human resources available, size of the local market and environmental vulnerability (EURISLES 2002).

A number of proposals have been put forward by the EURISLES commission for improved island development policy. These include (EURISLES 2002):

- The need for EU legislation to evolve (i.e. article 158)
- Differentiation of islands in the statistical nomenclature
- Maintaining the solidarity effort of the structural policies,
- Reshaping of the State aids regime
- New forms of governance resting upon consultation, coordination and innovation

However, these policies should not ignore the importance of the landscape as the fabric that meshes socio-economic and ecological processes. There any future policy has to be based on a holistic strategy as discussed in Chapter 14.

References

Aalen, F.H.A. (2001) Landscape development and change. In B. Green and W. Vos (eds.) Threatened Landscapes: Conserving Cultural Environments. Spon Press, pp. 3–20.
Cassar, L.F. (ed.) (2001) Training Package: Integrated Coastal Area Management. Part I – Training Manual. International Centre for Science & High Technology. UNIDO: Vienna.
Council of European (1979) Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds. Official Journal of the European Communities L 103: 1–18.
Council of European (1992) Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. Official Journal of the European Communities L 206: 7–50.
Council of Europe (2000). European Landscape Convention. European Treaty Series – No. 176. Florence.
Council of Europe/UNEP & Environmental Centre for Nature Conservation (1996) The Pan-European Biological and Landscape Diversity Strategy. A vision for Europe's natural heritage.
CPRM (Conference of Peripheral Maritime Regions) (2000) What Status for Europe's Islands. L'Harmattan Editions.
Delanoë, O., De Montmollin, B. and Olivier, L. (1996) Conservation of the Mediterranean Island plants. 1. Strategy for Action. IUCN: Cambridge.
Duke, G. (ed.) (2005) Biodiversity and the EU – Sustaining life, sustaining livelihoods. Conference Report. Stakeholder Conference held under the Irish Presidency of The European Union in partnership with the European Commission, 25–27 May 2004, Grand Hotel, Malahide, Ireland.
EURISLES (2002) Off the coast of Europe: European construction and the problem of the islands. Report for the Islands Commission of the Conference of the Peripheral and Maritime Regions (CPMR), pp. 150.
European Commission (2006) Regional Policy – Structural Funds (http://ec.europa.eu/regional_policy/funds/prord/sf_en.htm accessed 30 October 2006).
European Union (1997) Treaty of Amsterdam amending the treaty on European Union, the treaties establishing the European Communities and related acts. Official Journal of the European Communities C 340.
European Union (2004) Directive 2004/35/CE of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage. Official Journal of the European Union L143/56.
EUROSTAT (2006) General and Regional Statistics (http://epp.eurostat.ec.europa.eu/portal/page?_pageid = 0,1136162,0_45572076&_dad = portal&_schema = PORTAL last accessed, 28 December 2006).
Forman, R. and Godron, M. (1986). Landscape Ecology. Wiley: New York.
Hache, J-D. (ed.) (2000) Quel Statut pour les Îles d'Europe? (What Status for Europe's Islands?). Editions de l'Harmattan, Paris and Montreal.
Hiedanpää, J. (2002) European-wide conservation versus local well-being: the reception of the Natura 2000 Reserve Network in Karvia, SW-Finland. Landscape and Urban Planning 61, 113–123.
Hopkins, L. (2002) IUCN and the Mediterranean Islands: Opportunities for Biodiversity Conservation and Sustainable Use. IUCN.
IPCC (International Panel on Climatic Change) (2001) Climate change 2001. Impacts Adaptation and Vulnerability. Cambridge University Press: Cambridge.
IUCN (1994a) Guidelines for Protected Area Management Categories. CNPPA with the assistance of WCMC. IUCN: Gland, Switzerland and Cambridge.
IUCN Commission on National Parks and Protected Areas (1994b) Parks for Life: Action for Protected Areas in Europe. IUCN: Gland, Switzerland and Cambridge.
Kousis, M. (2001) Tourism and the environment in Corsica, Sardinia, Sicily, and Crete. In D. Ioannides, Y. Apostolopoulos and S. Sonmez (eds.) Mediterranean Islands and Sustainable Tourism Development: Practices, Management, and Policies. Continuum Publishers: London.

Marušič, J. and Jančič, M. (1998) Regional Distribution of Landscape Types in Slovenia: Methodological Bases. Ministry of Environment and Physical Planning. Ljubljana.

Mata Olmo, R. and Sanz Herráiz, C. (eds.) (2003) Atlas de los Paisajes de España. Secretaría General Técnica. Ministerio de Medio Ambiente-Universidad Autónoma de Madrid, 778 pp.

Meeus, J.H.A. (1995) Pan-European landscapes. Landscape and Urban Planning 18: 57–79.

Morey, M. and Martinez-Taberner, A. (2000) Environmental conservancy strategies in the Mediterranean Islands. In L. Trabaud (ed.) Life and Environment in the Mediterranean. WIT Press, pp. 345–386.

Papageorgiou, K. and Vogiatzakis, I.N. (2006) Nature protection in Greece: an appraisal of the factors shaping integrative conservation and policy effectiveness. Environmental Science and Policy 9: 476–486.

Pinto-Correia, T., Cancela d'Abreu, A. and Oliveira, R. (2002) Landscape units in Portugal and the development and application of landscape indicators. NIJOS/OECD Expert Meeting – Agricultural Landscape Indicators – Oslo, October 2002.

Royle, S. (2001) A Geography of Islands: Small Island Insularity. Routledge.

UNEP (1994a) Implications of Expected Climatic Changes on the Island of Rhodes. UNEP(OCA)/MED WG.55/2 rev. UNEP: Athens.

UNEP (1994b) Implications of Expected Climatic Changes on Malta. UNEP(OCA)/MED WG.55/3 rev. UNEP: Athens.

UNEP (1994c) Implications of Expected Climatic Changes on Cres/Lošinj Islands. UNEP(OCA)/MED WG.55/5 rev. UNEP: Athens.

UNESCO (1972) Convention Concerning the Protection of the World Cultural and Natural Heritage.

UNFCC (United Nations Framework Convention on Climate Change) (2006) The Kyoto Protocol to the United Nations Framework Convention on Climate Change (http://unfccc.int/resource/docs/convkp/kpeng.html, site accessed 30 October 2006).

Vogiatzakis, I.N., Griffiths, G.H., Cassar, L. and Morse, S. (2005) Mediterranean coastal landscapes: management practices, typology and sustainability. Project Report, UNEP-PAR/RAC. p. 50.

Vogiatzakis, I.N., Mannion, A.M. and Griffiths, G.H. (2006) Mediterranean ecosystems: problems and tools for conservation. Progress in Physical Geography 30: 175–200.

Wascher, D.M. (2001) European landscapes in transition: levels of intervention. In B. Green and W. Vos (eds.) Threatened Landscapes: Conserving Cultural Environments. Spon Press, pp. 129–138.

Washer, D. and Jongman, R. (eds.) (2003) European landscapes: classification, evaluation and conservation. European Environment Agency, Environment Technical Reports, Copenhagen.

WWF (1999) Natura 2000: Opportunities and Obstacles. WWF: Vienna.

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Part II
Mediterranean Island Landscapes

Chapter 7
Sicily

G. Benedetto[1] and A. Giordano[2]

Aeolian islands view from south of monte fossa felci (Photo: A. Giordano)

7.1 Introduction

Sicily is the largest (25,708 km^2) island in the Mediterranean with 1,039 km of coast and is surrounded by satellite islands of the archipelagos of Aeolian, Egadi and Pelagie (Fig. 7.1). The coasts of Sicily have diverse characteristics depending on which sea they face. In the north there are high and ragged cliffs with gulfs and

[1] Ministry of Environment, Italy

[2] WWF, Italy

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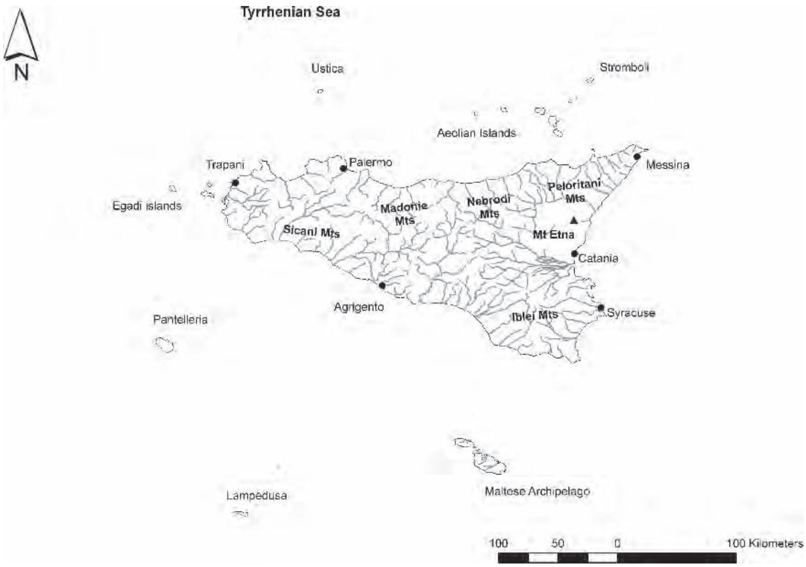

Fig. 7.1 Sicily, its main towns, satellite islets and river network (Adapted from GLOBAL GIS © 2001 American Geological Institute. With permission)

small pebble beaches, in the west and the south the coasts are flat with sand dune systems. In the eastern part of the island the coast can be divided in two different parts: above Catania it is similar to the northern coast while to the south it is low lying with gulfs and small bays.

Although predominantly hilly the landscape of Sicily is agricultural where both extensive and traditional agriculture are being practised. The island's fertile land has historically been exploited for agriculture following the pattern set by the Greeks and later the Romans who introduced large-scale agriculture. However, it was the arrival of the Arabs that advanced agricultural methods. Due to its central position in the Mediterranean Sea the island has always been a natural bridge between Europe and Africa which is reflected in a diverse fauna and flora but also cultural elements. The history of Sicily has been characterised by frequent invasions and conquests (Table 7.1) by peoples that succeeded one another met and clashed, all of which have left their characteristic marks on the landscape that overlaid and intertwined. These include unique cultural landscapes in the countryside but also in and around urban centres.

The history of the island is also linked to that of its active volcanoes such as Etna and Stromboli (part of the Aeolian islands). In the past eruptions and earthquakes and fairly recently immigration had their toll on the island's population which is currently c.5 million inhabitants. This makes Sicily the most populated island in the Mediterranean and the fourth more populated region in Italy with an

Table 7.1 Chronology of people/cultures in Sicily (Based on Leighton1999; Benjamin 2006)

Period	People/cultures
35000–18000 BC	Lower Palaeolithic (Aurignacian)
18000–9000 BC	Upper Palaeolithic (Epigravettian)
9000–6000 BC	Mesolithic
6000–3500 BC	Neolithic
3500–2500 BC	Copper Age
2500–1500 BC	Early Bronze Age
1500–1200 BC	Middle Bronze Age
1200–900 BC	Late Bronze Age
900–734 BC	Early Iron Age
734–480 BC	Colonial/Archaic
480–323 BC	Classical
323–241 BC	Hellenistic
241–31 BC	Roman Republic
31BC–476 AD	Roman Empire
476–535 AD	Gothic Occupation
535–827 AD	Byzantines
827–1060 AD	Arabs
1060–1198 AD	Normans
1198–1266 AD	Swabians
1266–1282 AD	French
1282–1412 AD	Aragonese
1412–1713 AD	Spanish
1713–1720 AD	Piedmontese
1720–1734 AD	Austrians
1734–1860 AD	Bourbons
1860 – present	Italian State

increase in population of 1.7 per thousand inhabitants due to more births and fewer deaths and recent immigration. The population density of the region is 189 inhabitants per km^2 compared to average 192 for Italy, although there are notable variations between the coastal zones and the hinterland. For example, the area of Enna the only non-coastal province of Sicily has a density of 69 inhabitants per km^2 compared to 292 for Catania (Regione Sicilia 2002).

The island had a pioneer role in the history of nature conservation in Italy. To date there have been successful cases where protected areas have generated income for locals through alternative tourism but also cases where conflicting interests have overridden the designation of protected areas. Sicily is also the pioneer among the Mediterranean Islands on extensive construction (buildings, roads) particularly along the coastal zone as well as illegal hunting and the lack of conservation law enforcement. The coastal zone in particular is under intense pressure following also the abandonment of the countryside which in some places started as early as the mid-19th century. As a result landscape modification and fragmentation due to anthropogenic activities have contributed to habitat degradation and resulted in biodiversity loss. Nevertheless, Sicily retains a variety of habitats that makes it a repository of high biodiversity. These include unique stands of endemic mountain species such as *Betula aetnensis or Zelkova sicula* but also extensive wetlands in Biviere di Gela and Vendicari (near Noto), the lake of Pergusa (Enna), and the saltpans of Trapani and Paceco (Regione Sicilia 2002).

7.2 Physical Environment

Sicily has a dominant hilly (62% of its surface) and mountainous character (c.24%) while 14% of the island is flat. Agricultural landscapes of the hills characterise much of the island and link the highest places and the plains (e.g. the largest plain at 430 km^2 is that of Catania between the Etna and the Iblei mountains). Northern Sicily is characterised by the so-called Sicilian Apennine located from east to west (that is, from Capo Peloro to Fiume Torto) by the Peloritani Mountains (highest peak 1,374 m at Montagna Grande), the Nebrodi mountains (1,847 m at the highest peak Monte Soro), the Madonie mountains (1,979 m at Pizzo Carbonara the highest peak) and then the mountains of Trabia, Palermo and Trapani. The centre-west part of the island is characterised by the Sicani Mountains, the Belice Valley, the Rivers San Leonardo and Sosio (Fig. 7.2) and by plateaux of gypsum. The Erei Mountains are further east between Enna and Caltanissetta, while towards the south-east there is the Hyblean Plateau (Monte Lauro is 986 m high) with its river valleys that sometimes present high and steep cliff banks. In the north the landscape is characterised by the imposing presence of Etna (Fig. 7.3), which occupies 1,600 km^2. At 3,350 m, it is the highest active volcano in Europe. Etna is surrounded by the rivers Alcantara to the north and Simeto to the south-west. South of the river Simeto, the lake Biviere di Lentini is found, which is now completely artificial after a series of land reclamation projects.

7.2.1 Climate

The island has a Mediterranean climate, with hot summers and mild winters. Rainfall is almost absent during the summer and is concentrated in the winter, which is the most humid season; conversely, summers are dry and sometimes with torrid climate. During spring, the rainfall, cloud cover and relative humidity progressively decrease and increase during autumn. However, the Sicilian climate is complex. At least four different climate types can be recognised that vary according to geomorphological characteristics: there are the mountain chains to the north of the island, the stand-alone Etna system, the internal part of the island and the coasts. If the Peloritani, Nebrodi and Madonie have harsh winters and temperate summers, the coasts have mild winters and very hot summers (Regione Sicilia 2002).

Fig. 7.2 View of the valley of Sosio (Palermo province), nature reserve and Important Bird Area for various species of birds of prey currently managed by the Agency for State-Owned Forests (Photo courtesy of A. Giordano) (*See Colour Plates*)

7.2.2 Geology, Tectonic History, Soils

Geologically Sicily represents the connection between the North African and Apennine chains of mainland Italy which form an orogenetic system resulting from the deformation of different palaeogeographic domains (AA.VV 1987, 1995). From the Eocene (40 million years ago) to the Quaternary (c.1.8 × 10^6 years ago), these domains have undergone several deformations within a fold structure whose

Fig. 7.3 Northern flank of Etna viewed from the Nebrodi Mountains (Photo courtesy of A. Giordano) (*See Colour Plates*)

evolution involves the Calabrian domains first, and then the more external areas that are reached in the Plio-Pleistocene by the compression front where the Euro-Asiatic plate and the African plate coalesce. Two systems were then created: an intact system that forms the African foreland basins, and another system characterised by a tectonic complex with strata and plates oriented towards the south which form the Apennine-Maghreb chain. The same processes that led to the formation of the Sardo-Corsican massif and the opening of the Tyrrhenian Sea have contributed to the formation of the Sicilian mountains. While these mountains were rising in the north, a depression was forming in the south. This is the 'trench of Caltanissetta', where the sediments arising from the erosion of these mountains accumulated.

Fig. 7.4 View of the Peloritani Mountains SCI and SPA from the Dinnammare summit at 1,152 m; Etna is in the background (Photo courtesy of A. Giordano) (*See Colour Plates*)

Towards the south-east, the Hyblean plate, characterised by coral reefs until 8 million years ago, emerged from the sea to form a limestone plateau. These elements underpin the geological diversity that can be found in Sicily (AA.VV 1987, 1995).

The Peloritani Mountains are formed by crystalline rocks that in places are covered by sediments while the Nebrodi Mountains are characterised by sedimentary rocks (mainly sandstones, clays and conglomerates). Consequently, the landscape of the Peloritani Mountains is poorly vegetated and is characterised by steep relief (Fig. 7.4), while the Nebrodi landscape is gentle and rich in woodlands. The Madonie Mountains are formed by limestones and sandstones-mudstones; and are also characterised by gentle relief forms and healthy woodlands. The mountains of Palermo and Trapani have limited woodlands, are mainly clayey and are characterised by flat areas; however, they also have limestone and limestone-dolomite formations with karstic features. Limestones are also found in the Sicani Mountains and in the central and western areas located between the Platani and Salso rivers, where gypsum and sulphur plateaus are present together with deep karstic cavities (AA.VV 1987, 1995). The Erei Mountains are formed by sand-rich calcarenites and sandstones, while the Hyblean Plateau is formed by rocks that belonged to a platform that consisted initially of limestone, but then turned onto mudstone and clays sometimes interrupted by limited basaltic lava flows. To the north, the Catania plain is alluvial and is crossed by the river Simeto and its two tributaries, the rivers Dittaino and Gornalunga (AA.VV 1987, 1995).

Etna was formed around 700,000 years ago in the Upper Pleistocene from underwater explosions that took place in the 'ante-Etna gulf', between the Peloritani and the Iblei mountain ranges. The Faraglioni and the Isola Lacea in front of Aci Trezza were also formed by these eruptions, which filled the gulf and were subsequently covered by alluvial deposits that created the plain of Catania. Only a few traces are left of the earliest volcanic structures (e.g. Rocca Capra in the Valle del Bove), because around 150,000 years ago a series of violent eruptions reduced Etna's height by causing the collapse of the top of the volcano, and forming on its eastern flank the Valle del Bove, an amphitheatre-like valley c.6 km wide. Despite being located on a compressive tectonic area, Etna's eruptions are caused by a divergent action that results in the emission of basaltic lava from faults and fractures oriented at right angles to the areas of lithospheric compression. These fluid lava flows created gentle slopes that were subsequently covered by explosive materials to form steeper cones. The first eruption dates back to 6200 B.C.; many subsequent eruptions have occurred which have not only created a variety of volcanic forms, but also reached the sea, destroying villages, fields and roads. Sicily's other active volcano is on the island of Stromboli, the northernmost of the Aeolian Islands; it has a conical shape entirely formed by volcanic material (AA.VV 1987, 1995).

The landscape of Sicily is dominated by eroded soils, Eutric and Calcaric Regosols, and soils with accumulation of carbonates and more soluble salts such as Eutric and Calcaric Cambisols. On igneous rocks acid soils with organic matter accumulation on surface dominate while volcanic soils are found in the area of Etna. On low lying coastal areas where agriculture is the principal land use superficial soil erosion and mass movements are very common and result in low soil organic matter content. Around Etna lava effusions and ashes depositions contribute to soil instability (Constantini et al. 2004).

7.3 Biotic Elements

7.3.1 Flora and Vegetation

The geographical position of Sicily, its varied morphology and its climatic history encourage the presence of wide range of habitats from Mediterranean maquis to residual forests of the glacial era. This is due to the climatic change the last 2 million years that allowed trees typical of cold climates such as beech and birch to colonise at the end of the cold stages and because the island's topography gives rise to a wide range of meteorological conditions between high mountains and the coast. Today Sicily's flora comprises about 2,700 species (Delanoë et al. 1996) of which 11.5% is endemic, although some estimate that this number is higher c.3,000 species (Brullo et al. 1995). The island's flora display common floristic links with south Greece, north-west Africa but comprises also European, Eurasiatic and Circumboreal elements (Table 7.2) which probably arrived in Sicily during Pleistocene glaciations. There are also a number of palaeoendemic species relicts of the Tertiary flora (Table 7.2).

Floristically the Madonie Mountains are among the most important areas of the island. There are forests of oak, together with relicts of evergreen forest dominated by *Ilex aquifolium* as well as high numbers of endemics and narrow endemics. The

Table 7.2 Examples of floristic elements in the Sicilian flora

Floristic element	Species
North African	*Carex intricata, Gagea mauritanica, Lonas annua*
Aegean, Balkan	*Cardamine graeca, Cistus parviflorus, Putoria catabrica*
European, Eurasiatic & Circumboreal	*Asplenium septentrionale, Carex laevigata, Equisetum palustre*
Relicts	*Abies nebrodensis, Astracantha nebrodensis, Odontites bocconei*

Fig. 7.5 Stands of the endemic *Betula aetnensis* on Etna (Photo courtesy of I. Vogiatzakis) (*See Colour Plates*)

active volcano of Mountain Etna in the east is also rich in endemics such as *Astragalius siculus* and *Genista aetnensis*. The mountains are the most southern station for a number of northern and central European species. For example, Sicily is the European southern limit for the beech (*Fagus sylvatica*), which is widely present in the Nebrodi woodlands together with the yew (*Taxus baccata*), while on the Etna the geographical isolation has allowed the evolution of an endemic birch species (*Betula aetnensis*) (Fig. 7.5) and the development of magnificent forests of *Pinus nigra*. Both on the main island and on the smaller islands that surround it, rich vegetation is present due to the vast diversity of environmental conditions and their geographical isolation. The Egadi islands off the west coast support several endemics including the cabbage species *Brassica macrocarpa* (Davis et al. 1994). According to IUCN 3% of the island's flora belong to globally threatened taxa and 6% are locally threatened (Delanoë et al. 1996) while a recent study (De Montmollin and Strahm 2005) identified 8 vascular plants of Sicily at the brink of extinction (Table 7.3).

The vegetation of the island is represented by rich Mediterranean maquis characterised by species such as *Erica arborea, Spartium junceum, Arbutus unedo* and *Pistacia lentiscus*. Mediterranean-type forests are widespread on the mountain ridges of Peloritani, Nebrodi and Madonie mountains, with patchy extension also in other few places of the island, covered in many part by substeppic grassland, a protected habitat by the EU. In widespread wetland areas along the coast the vegetation can tolerate extreme conditions such as high salt concentration in the soil and in the air; dominant species include *Salicornia sp*. and *Suaeda fruticosa*. Remnants of previously widely distributed dunes with *Juniperus oxycedrus subsp. macrocarpa* are found on the southeastern coast. Although the anthropogenic influence has intensified in recent centuries, in some cases the native vegetation has recolonised the transformed areas. For example, in the Peloritani Mountains which were reforested at the end of 1800, to deal with hydrogeological hazards facing the city of Messina, the native vegetation slowly replaces the introduced species used for reforestation.

7.3.2 Fauna

The climate and the presence of important wetlands provide stopover habitats during the winter for many bird species, which migrate between Europe and Africa. To date, 324 different species of birds have been recorded in Sicily and among nesting species, 35 are included in Annex I of the Birds Directive. These include the last nesting pairs of Bonelli's eagle (*Hieraaetus fasciatus*) and Egyptian vulture (*Neophron percnopterus*), several colonies of lesser kestrel (*Falco naumanni*) and some colonies of Eleonora's falcon (*Falco eleonorae*) present on the Aeolian archipelago and in the process of colonising other Sicilian islands. The rock partridge (*Alectoris graeca whitakeri*) identified by Priolo (1970, 1984)

Table 7.3 Sicilian plants at the brink of extinction (De Montmollin and Strahm 2005)

Species	Location	Population (individuals)
Abies nebrodensis	Madonie mountains	30
Bupleurum dianthifolium	Marettimo island (Egadi Islands)	300–500
Bupleurum elatum	Madonie Mountains	400–600
Calendula maritime	Northwestern Sicily	n/a
Hieracium lucidum	Monte Gallo	400–500
Petagnaea gussonei	Nebrodi Mountains	n/a
Viola ucriana	Mountain Pizzuta	n/a
Zelkova sicula	Iblei Mountains	200–250

n/a: not available.

is also endangered. This species is endemic to the island and is the object of intense hunting and poaching. Species like the Griffon vulture (*Gyps fulvus*) and *Porphyrio porphyrio* disappeared in the past as a result of human activities. However, they have both been the object of reintroduction projects and they can now be seen in protected areas: the Griffon vulture in the Parco Regionale dei Nebrodi and the *Porphyrio porphyrio* in the Nature Reserves of the ‘Biviere di Gela’ and ‘Foce del Simeto’.

With respect to mammals, the last wolf (*Canis lupus*) was killed around 1930 on the Nebrodi Mountains as were the deer (*Cervus elaphus*) and the fallow-deer (*Dama dama*). The fox *(Vulpes vulpes*), the hedgehog (*Erinaceus europaeus*), the rabbit (*Oryctolagus cuniculus*) and the marten (*Martes martes*) are still rather common, while the wild cat (*Felis silvestris*) and the porcupine (*Hystrix cristata*) are both subject to intense poaching. The hare (*Lepus corsicanus*) and the dormouse (*Myoxus glis*) have most likely been introduced to Sicily in historical times. Amongst the Chiroptera protected at European level, bat species such as *Rhinolophus ferrumequinum, Rhinolophus hipposideros* and *R. mehelyi*, as well as *Miniopterus schreibersii* and *Myotis capaccinii* (Fornasari et al. 1997) are present on the island.

Reptiles and amphibians are represented by few species, e.g. *Testudo hermanni, Chalcides chalcides, Chalcides ocellatus, Hyla intermedia, Bufo bufo, Bufo viridis* and *Rana bergeri*. Uniquely, there are African species which occur nowhere else in Italy such as the *Discoglossus pictus* (Scalera 2003). Insects are represented not only by Mediterranean species, but also by relict species of glacial eras and African or Oriental species isolated on the island since the geological times when Sicily was still connected to the African continent. Further evidence of this connection are the fossil remains of elephants and dwarf hippos found in several Sicilian areas.

7.4 Cultural Landscapes

An environment so diversified through such complex history (Table 7.1) has created a variety of cultural landscapes. The Sicilian landscape is predominantly agricultural: the 85% of 1,504,240 ha of agricultural land are used by around 365,000 farm businesses that are mostly family-run. Agricultural practices vary according to the area where they are carried out: intensive agriculture (mainly horticulture, fruit and flowers) is practised along the coasts, while traditional agriculture with minimal mechanical means and chemical inputs to produce cereals and olives still exists in the hilly central regions.

According to the historical records the first farmsteads date back to the Greek period (see Table 7.1) when organised production structures started to form close to the town centres they were supplying. This organisational structure continued in the following periods and is most likely the origin of one of the characteristics of the agricultural landscape of Sicily, which is dotted with typical rural buildings and farmhouses, called *bagli* (Fig. 7.6). Thus, the Romans found an agrarian structure already organised that they adopted. However, they superimposed on this existing

Fig. 7.6 Agricultural landscape between Vicari and Prizzi (Palermo), Sicani mountains an Important Bird Area (IBA). (Photo courtesy of A. Giordano)

structure the large-scale wheat production that made Sicily known as the 'granary of Rome'. This led to the construction of aqueducts and rural roads, and to centuriation, i.e. the division of land into 720 m by 720 m parcels called *centurie*, that were given to colonisers or used as public grazing land.

During the Byzantine period, agricultural supplies were mainly guaranteed by Syracuse, while the remaining towns relied on other activities, such as dockyards in Catania and sulphur manufacture in Agrigento. Towns were linked to a populated countryside organised in villages and agricultural complexes, which also reflect a concentration of land ownership. Subsequently, the countryside became the property of the Emperor and the Church. In 590 the largest landowner was Pope Gregorio Magno and the land was managed by the bishoprics. When the Arabs arrived in

Sicily, the population was greatly reduced due to epidemics, wars and emigration, and land progressively fell into the hands of the new invaders. This step was important to interrupt the creation of large estates and the organisation of the countryside changed thanks to the introduction of concessionary systems and to the right of inheritance. The Arabs contributed greatly to the agricultural development of the island. Not only they began again the cultivation of cereals on a large scale (mainly in the central areas), but also they developed a large variety of coastal crops using new techniques (from mulberry trees to citrus fruit, pistachio nuts and dates), improved the irrigation systems and increased the amount of land available to agriculture by clearing new lands. Towards the end of the Arab period (see Table 7.1) and with the beginning of feudalism, the whole agricultural system deteriorated. Many cultivated areas were abandoned, woodlands were destroyed, to make space for pastures, and the rural population declined. The agriculture activities resumed during the reign of Federico II. During the Norman period the Sicilian landscape was reorganised, many villages disappeared and towns were fortified, but agriculture suffered a progressive and relentless decline that was to last for centuries through the Spanish period, aggravated by a combination of civil wars, military occupations, plague and deep social crisis.

Poor agricultural management resulted in such extensive soil erosion that the hydraulic regime of entire areas of the island changed: on one hand flooding increased, and on the other rivers that were perennial turned into seasonal torrents. The big catastrophes of the 17th century, i.e. epidemics, earthquakes and Etna's eruption, started a process of reconstruction and transformation. The baroque culture of the time had the opportunity to express itself in the construction of towns like Noto, and in modernising and refurbishing towns like Catania, Syracuse and Modica. In the same period, villages and small towns were created in the countryside of western Sicily; these centres were related to the local gentry that owned nearby large estates and were important in providing the labour needed to cultivate these lands (Sereni 1961).

At the beginning of the 18th century, Sicily was a backward region with poor road infrastructure and outdated methods; the central areas were still characterised by extensive agriculture, while citrus fruit cultivation prevailed on the coasts. Estates started to be fragmented, especially in the eastern part of the island, to give way to new forms of land allocation (*enfiteusi*) devised by the big landowners for long periods. This modified the hilly landscape of the Etna region and the Hyblean plateau, and created a new agricultural landscape based on small and clearly defined land estates (Sereni 1961).

The new needs of society, especially on the mainland, resulted in Sicily becoming a source of timber. This led to a dramatic reduction in the woodland heritage of the island in the early 1900s. The poor soils forced people to look for new areas to live and the land stability problems became more serious, leading to flooding, landslides and soil collapses. Levels of poverty also increased and around the middle of the 19th century a third of the agricultural population (around 700,000 persons) was forced to abandon the rural settlements and move to the towns. In the meantime the Church understood that the political climate was changing and started to sell its properties. This reinforced the position of many individuals with an availability of cash, and especially the aristocracy. When Sicily became part of the Kingdom of Italy (1860), three quarters of the land belonged to rich landowners that were exploiting the farmers to cultivate their land and saw no advantage in the modernisation of agricultural practices. Despite the modernisation attempts carried out through the construction of some railway stretches and of roads such as the Messina-Palermo and the Messina-Syracuse, the island remained seriously backward and neglected. The poor found a solution in emigration to the Americas and at the beginning of the 20th century Sicily lost around 1.5 million inhabitants. The earthquake of Messina in 1908 caused over 100,000 deaths. Immediately after World War I, the Fascist regime revived the concept of Sicily as the 'granary of Italy', but the cultivation of cereals on a large scale was not well managed and impoverished the soils. The cultivation of citrus fruit, tomatoes and vineyards resumed only after World War II, thanks to a series of water projects.

Currently the Sicilian landscape is mainly agricultural. Durum wheat is still cultivated in the central part of the island (Fig. 7.7), while horticulture, fruit crops and floriculture are favoured in areas with better water availability and more favourable soil and climate conditions, e.g. in the province of Trapani, the Tyrrhenian coast of Messina, the Plain of Catania, the areas south of Syracuse and Ragusa, and the land along rivers. However, the presence of permanent greenhouse structures has caused a radical change in the landscape aesthetics, as in the province of Ragusa where 7,482 ha are affected. Tree cultures consist of olive trees (on the central hills), almonds and pistachios (Agrigento, Caltanissetta and the area of Bronte on the Etna), hazelnuts (Peloritani, Nebrodi and the area of Sant'Alfio on the Etna) and carobs (on the Hyblean plateau characterised by dry stone walls that separate the different land estates). Citrus fruit trees are still present in the traditional areas of the Plain of Catania, Syracuse, Agrigento and those areas of the Conca d'Oro near Palermo that have managed to escape illegal construction). Vineyards have recently recorded a significant increase and show different characteristics according to the type of implant; traditional vineyards tended as small trees and on terraces are still visible (Regione Sicilia 2002).

The agricultural landscape contrasts with the urban landscape. Although equally complex the urban landscape varies from planned urban landscape rich in historical and artistic heritage, to post-modern urban landscape related to shopping malls, industrial areas and other structures far from the towns but easily connected via the transportation networks (Regione Siciliana 2002). Outside what are now the major island towns the urban landscapes are characterised by a series of historical elements which are still preserved and clearly recognisable. For example, elegant towns of the Greek period such as Syracuse and Agrigento are organised around squares, meeting points, temples and theatres. A specific landscape characterisation defined as 'historical centre of ancient origin' thus exists, whose features go beyond Greek or Roman artefacts.

According to the terminology adopted by the Regional Government for the production of landscape plans, the 'historical centres of medieval origin' must also be considered. These are usually clearly defined and characterised by defensive systems consisting of a castle and its fortification walls (Fig. 7.8). The 'newly estab-

Fig. 7.7 Typical agricultural landscape of central Sicily (Photo courtesy of A. Giordano) (*See Colour Plates*)

lished' historical centres include the central nuclei of residential developments related to the cultivation of large land estates dating back to the 15th and 16th centuries. The same definition applies to the central nuclei established by the aristocracy to reconstruct villages or portions of towns destroyed by natural catastrophes and dating back to the 18th and 19th centuries. Wonderful residential structures are often present, which were used as holiday homes by noble landowners.

Just as the agricultural landscape has characterised certain areas, different landscape types established themselves where other production activities were prevalent. The landscape of saltpans is spectacular comprising buildings, pans and fauna which combine aesthetic, historical, cultural and natural values (Fig. 7.9). Some saltpans are still in operation in Trapani and Marsala despite

Fig. 7.8 The Morgana castle between Vicari and Prizzi, on the Sicani Mountains (Photo courtesy of A. Giordano

Fig. 7.9 Sunrise on the Salt Pans of Trapani and Paceco, nature reserve, SCI and SPA, managed by WWF Italy (Photo courtesy of A. Giordano) (*See Colour Plates*)

being encroached by expanding urban areas. The landscape of the sulphur mines in the provinces of Caltanissetta, Enna and Agrigento is also evocative. In the 19th century, around 200 sulphur mines existed, which employed 40,000 persons working in terrible conditions.

7.5 Recent Environmental Changes

Sicily has at present c.30 industrial areas located mainly in the provinces of Catania and Palermo. After World War II, when oil was found in the south-east of the island, it was possible to imagine a future based on this resource. However, the oil reserves were soon found to be limited. The refineries of Augusta and Gela, constructed after the oil was found became later large petrochemical centres, together with Priolo and Milazzo. Lately, these areas have been identified as presenting an elevated environmental risk. The landscape and the socio-economical fabric have been radically transformed by these industrial centres. The creation of new work opportunities contributed to the abandonment of the countryside and of traditional activities.

New infrastructures have scarred the landscape and the coastlines. Chimney stacks, chemical depots and light masts dominate the landscape and the contrast with the surrounding landscape is strong. This is not the only problem. The creation of industrial areas, promoted by the need to create new jobs, has caused serious environmental and social problems. Frequencies of genetic diseases, respiratory illnesses, spontaneous abortions and cancer rates higher than the national average have been recorded around Priolo, Augusta and Milazzo. Sometimes, aquifers and boreholes are so contaminated that they can no longer be used for potable water supply. In addition to the poorly managed industrial issues, uncontrolled, and often illegal, building developments have been extremely harmful for the Sicilian environment, especially when causing the disappearance or alteration of beautiful stretches of coastline.

A study carried out by WWF (1996) based on satellite data has documented how 63% of the Sicilian coastline is subject to complete urbanisation within an area stretching from the coast up to 1 km inland; if non-adjacent urban areas and infrastructure are also considered, this percentage increases to 74%. The percentage rises to 82% if the areas occupied by any type of infrastructure are considered. According to WWF calculations, only 18% of the coastlines are completely free from infrastructure. Over more than 1,000 km of coastland, only 37 coastal areas are completely free and are at least 3 km wide, which is a very serious situation considering that none of these areas is more than 7.5 km long. Since 1996 the situation has certainly deteriorated, in particular with respect to the existing building density and due to the fact that laws have been approved to grant a pardon for illegal buildings. Illegal construction is a phenomenon that is present on the whole Sicilian territory and involves protected nature areas (e.g. the mouth of the river Simeto), archaeological areas (e.g. the Valley of Temples in Agrigento), areas at risk (e.g. the flanks of the Etna), historical centres (e.g. unauthorised intervention in listed buildings), productive areas (e.g. the industrial area of Trapani), urban suburbs and the countryside. This plague has marked the territory, distorted the beauty of some areas and modified the natural systems through illegal water abstraction and unauthorised discharges. Public infrastructure of doubtful utility or necessity has been constructed to create employment. The beds of many streams have been straightened and engineered using concrete, thus creating environmental problems along the coasts (coastal erosion is a consequence of the streams and rivers not discharging enough sediments into the sea) and decreasing the natural recharge of the aquifers.

The exponential growth of leisure sailing has led to the creation of tourist ports, often built without the necessary investigations on current dynamics and possible coastline modifications. Consequently coasts have been damaged and ports have silted up, the use of artificial reefs has increased, which has started a vicious circle of coastal erosion with serious financial repercussions. Despite this, the construction of new ports continues to be promoted, although the projects are not accompanied by serious studies on their possible consequences, resulting in a never ending process of coastal erosion patched up by state-funded coast protection projects.

Since the end of the 1960s, Sicily has been in the grip of a ‘road obsession’, that is the excessive construction of roads everywhere, even in practically pristine natural habitats, with serious consequences on land stability and habitat integrity. Roads have also permitted the expansion of illegal and damaging activities such as forest fires, poaching, illegal construction and illegal water abstraction. The construction of ports, tourist resorts and new roads is ongoing and all these activities are included in the Regional planning programme, which also foresees the creation of new hotel complexes in protected areas. A Law Draft has recently been submitted to the Sicilian Regional Assembly for the creation of four new tourist centres in extremely delicate areas such as the Parks on Etna, Nebrodi and Madonie. Hotels with hundreds of rooms, large parking areas and golf courses have been authorised in various Sites of European Importance despite the evident impact they would have in areas where water is insufficient the whole year round for the local residents and agriculture. It seems that the only solution for the economic development of Sicily is the creation of new tourist ports (an average of one port every 20 km of coast), new developments in pristine landscape and nature areas, new roads such as the Ionico-Tirrenica that will pass through several Nature Reserves and a Regional Park.

In addition, wind farms are being suggested in areas where they will have a negative impact on protected bird species. This is proposed in the absence of a regional energy plan that identifies the suitable areas for the location of wind farms and clarifies the different energy sources, forecast savings, use and distribution strategies for an island that currently exports its energy surplus.

Most of the forest fires are anthropogenic; these fires contribute to the degradation of the natural heritage of the island and cause serious land stability problems, soil loss and salinisation, as well as climate change on a local scale. According to the data collected by the Italian Civil Protection Service, in 2003 alone 618 forest fires raged across Sicily, affecting 17,000 ha of land, of which 8,000 ha were covered by woodland (Relazione Annuale della Protezione Civile 2003).

Intensive agriculture must also be cited in relation to the environmental impacts it causes. Agriculture has undergone significant changes, but after World War II the production of crops that are poorly suited to the climate and water availability of the island has intensified. This has led to an increase in the use of agrochemical products: after the large agricultural areas of northern Italy (such as the Po Plain), Sicily and Campania are the major users of insecticides, fungicides and weedkillers. Although lower than the national average, the use of inorganic fertilisers is also significant. On the other hand, organic agriculture has increased and now 10,000 farms cultivate around 130,000 ha (Regione Sicilia 2002). Agritourism has also grown which has resulted in the production of high quality agricultural products and the restoration of abandoned or seldom-used buildings.

Unsustainable agriculture has often been supported by EU funds. Together with other southern Italian regions, Sicily was included in the list of ‘Least Favoured Areas’ characterised by poor development, which provided substantial funds that were often misused. Since the 1990s, due to changes in the Common Agricultural Policy, there has been a move towards different productions, since the financial help is no longer related to quantity only (which in the past had led to the destruction of excessive production), but also on quality, rural regeneration, extensive agriculture and alternative uses of the land. Positive impacts have also been registered in the silvicultural sector: woodland improvements have affected more than 4,000 ha and new trees (chestnuts, pines, carobs, cherries and other) have been planted.

Until recently, the creation of high impact tourist infrastructure was very limited. Also, the building of large tourist resorts having thousands of beds in two very important nature areas, such as Vendicari and Torre Salsa, met with strong opposition. Despite the difficulties, nature reserves were created instead. Although tourism is very intense during the summer period and the high number of visitors has a strong impact on the environment (especially in the smaller islands), cultural tourism has been able to make good use of the existing infrastructure and enjoy the historical, natural and food heritage of the island. Parks and reserves have given a new impulse to the creation of bed and breakfasts, and on the refurbishment of existing buildings, thus improving the presence of a less invasive type of tourism. However, planning applications have been submitted for the building of tourist resorts (even in protected areas that are part of the Natura 2000 network) in the past few years. Even more seriously, some of these applications have been approved by the Regional Government.

7.6 Landscape Conservation

Sicily was one of the first Italian regions to have laws related to the creation of parks and nature reserves. Regional law no. 98, dated 1981, was produced after the vociferous complaints of environmental associations against the construction of a coastal road near San Vito Lo Capo (Trapani). This road would have destroyed the beauty of this coast, which is rich in Mediterranean maquis and nesting sites for the Bonelli eagle. Following a local street protest in May 1981, the coastal road project was scrapped and the first regional nature reserve, Lo Zingaro, was created and managed by the Agency for State-owned Forests. From 1981 to date, 76 regional nature reserves and 4 regional parks (Etna, Madonie, Nebrodi and Alcantara) have been created (Regione Sicilia 2002). Some reserves protect very small areas such as caves while others are very large sometimes covering thousands of hectares (Table 7.4). Three marine reserves also exist and include the island of Ustica (Palermo), the Egadi Islands (Trapani) and the Isola dei Ciclopi (Palermo), for a total of 70,566 ha (Regione Sicilia 2002).

Not all the reserves are well managed, and sometimes protection policies are not compatible with the reasons at the basis of the creation of the same reserves. In some, management focuses mainly on economic aspects (e.g. massive tourism) more than conservation aims while tolerating incompatible activities (caving, new roads, buildings, massive sports events) thus contradicting the reason for the designation of the reserves. The management of these reserves is given by law to different authorities, such as Provincial administrations, the Agency for State-owned Forests, environmental associations and University consortia. Sometimes the bureaucratic structure of these authorities and internal politics nullify, slow down or change drastically the concept of protection. In other cases, the management has been successful and has produced new economies relying on the reserves, thus transforming the opposition of local communities into consensus. One such example is the Nature Reserve of the Salt Pans of Trapani and Paceco, created by the Region and managed by WWF since 1996 (Fig. 7.9). When WWF's management began, the situation was critical: although these were private areas allocated to the production of sea salt and already subject to several protection measures, illegal activities such as landfills and buildings were occurring. These degraded the landscape and seriously threatened the presence of birds. Disturbance to birds varied from direct, i.e. poaching or indirect through recreational activities such as motocross. The creation of the reserve and the enforcement of the rules for the protection of this area encountered much opposition. However, with time it was possible to demonstrate that the effective protection of the area did not interfere with the traditional salt production activities, and created new sources of income. The WWF management authorised several projects for the restoration of abandoned salt pans (thereby increasing the production of salt), old farmhouse (*bagli*) and windmills for total investment of 20 million euros. Thousands of visitors took advantage of guided tours of the Reserve and decided to spend time in the area, using local facilities. After a few years the salt produced with traditional methods obtained a quality stamp of approval since it came from a protected area. The presence of birds increased year after year, offering valued experiences to visitors within the protected area, and also to those travelling on the road that runs close to the salt pans.

Table 7.4 Protected Areas in Sicily (From Italian Ministry of Environment 2006)

Protected area category	No.	Size (ha)
Natural regional parks	4	185,551
Regional nature reserves	76	85,164
Other protected regional nature areas	1	5
RAMSAR wetlands	2	1,706
Natura 2000 SCI and SPAs	218 + 29	546,387

Many other protected areas, such as Lago Preola e Gorghi Tondi (Trapani, managed by the WWF), Lampedusa (Agrigento, managed by Legambiente), Vendicari (Syracuse) (photo) and Lo Zingaro (Trapani, both managed by the Agency for State-Owned Forests) have brought benefits in terms of conservation and new sources of income. These protected areas were identified by the Regional administration through its internal authorities (Regional Council for the Protection of the Natural Heritage, Regional Department for the Landscape and the Environment). In 1991 the Regional Reserve Plan was produced, although this has not yet been fully adopted. Other areas have been identified by the Natura 2000 network, along the same lines used by other EU Member States to identify areas that were hosts to animals, plants or habitats included in the Birds and Habitats Directive (Council of Europe 1992). The Regional administration followed the advice of the local universities and designated 218 Sites of Community Importance (SCIs) and 29 Special Protected Areas (SPAs) for a total of 546,387 ha (Table 7.4). Currently the Sites of Community Importance are only at the proposal stage and will have to be approved by the EU. These sites contain more than 60 significant habitats characterised by the presence of important numbers of species protected under the Habitats Directive. These proposed areas are protected when they overlap with existing managed parks and reserves. If they are outside the existing parks and reserves, they become subject to partial alteration, transformation, reduction and destruction, leading at times to the complete disappearance of the protected area. More recently, the Regional administration has identified new Areas of Special Protection, thus modifying the surface of the 14 IBAs (Important Bird Areas) identified in Sicily since 1989. Due to the limited number of protected areas under the Birds Directive, the European Court of Justice considers these IBAs to be the scientific point of reference for the same Directive. In order to avoid the financial sanctions against Italy for the limited number and dimensions of the Areas of Special Protection, the Regional administration has enlarged these areas, although their new boundaries are not known yet. Two areas already protected by the regional and national legislation have been identified as Ramsar Sites, since they are humid areas of international importance (Vendicari and Biviere di Gela); other areas are under investigation as possible Ramsar Sites (Salt Pans of Trapani and Paceco, Stagnone di Marsala).

In 2000 the Aeolian Islands (Fig. 7.10) were identified as UNESCO World Heritage Site for their particular type of volcanism; to date, these are the only Italian sites identified for their natural aspects. Other forms of landscape protection are guaranteed by ‘landscape’ restrictions that protect different widths of land around water bodies (sea, lakes and rivers), the mountains above 1200 m, all the protected nature areas, woodland, volcanoes and areas of archaeological interest (which are managed by the Regional Administration through the Department for Environmental and Cultural Heritage). Other forms of protection are offered by ‘hydrogeological’ restrictions implemented by the Department for Agriculture and Forestry and applied to several areas characterised by sensitive geomorphology. It must be noted that in Italy the term ‘hydrogeological’ in this context does not refer to aquifers but to slope protection for the prevention of landslides.

Fig. 7.10 Sunrise on the Strait of Messina, a migratory route of international importance (over 320 species of birds recorded till today) an SPA site (Photo courtesy of A. Giordano) (*See Colour Plates*)

Such restrictions are not respected in many areas and the bodies that should implement them nevertheless authorise the building of roads, residential and commercial areas, and holiday resorts. In these instances, there is an incomplete vision of what has been authorised and as a result, the landscape and the integrity of these areas are completely altered. However, the knowledge of the natural heritage and its partial protection has improved and the initiatives of different associations have strongly contributed to the protection of the environment and the fauna in particular. An important example is given by what happened on the Strait of Messina (Box 7.1) an internationally important area and the object of intense historical poaching on both sides of the coast (Sicily and Calabria). A national law approved in 1977 forbade the hunting of diurnal and nocturnal birds of prey, springtime hunting and the use of hunting huts on mountain and hill passes. However, in 1981 it became apparent that this law was not respected: thousands of birds of prey (including endangered species), black and white storks and many more bird species were killed by poachers when flying through the Strait of Messina.

Environmental associations such as the WWF, LIPU (Italian Association for the Protection of Birds) and Mediterranean Association for Nature (MAN) started a dangerous fight against poachers and demanded the respect of national and international laws. Such actions, carried out with the help of foreign environmental associations, are still ongoing and have brought excellent results with respect to the protection of birds that migrate towards Europe. Figure 7.12 (Giordano et al. 2005) shows how the reduction of poaching has continued over the years and this has stabilised the numbers of birds that use the Strait of Messina. Unfortunately the restrictions imposed by the EU on this corner of Sicily through the creation of an IBA and two

Box 7.1 Strait of Messina

The strait of Messina is a magical location where mythology, history, culture and nature coalesce to produce a unique environment (Fig. 7.11). Here the mythical monsters of Scilla and Charibdes (i.e. Sicily and Calabria) meet in the narrowest and most turbulent point of this section of the Mediterranean. Fish from the abyss come to the surface at night following periodic vertical currents, and the waters from the Ionian and the Tyrrhenian meet twice a day creating vortices and currents among the fastest in the world, which give origin to 35 different movements dictated also by the lunar cycle. In this unique location that has inspired poets and writers from antiquity, the Italian Government had plans to construct the longest bridge in the world, the bridge on the Strait of Messina. The initial project was rejected in 1992 by the ministries in charge but in January 2003 the project was resubmitted with modifications and a new environmental impact assessment. Despite omissions, contradictions and falsified information it obtained the approval of the Italian Inter-ministerial Commission for Economic Planning (CIPE). This has led to investigations by the Public Prosecutors in Rome and accusations by the EU of the infringement and violation of the Birds and Habitats Directives. At a time when marine routes are promoted in order to reduce road congestion, atmospheric pollution and related accidents, Italy has decided to unite Sicily with the mainland. Currently, the actual travel time by boat is 20 minutes while the trains need more time because the existing fleet has not been modernised in the last 30 years.

The company responsible for the project is funded by the state and to date has provided incomplete information about the timetable of the development and its impacts on the area. When the environmental impact assessment for the project was presented in January 2003, the only information that the company provided to the public was the length of the bridge, its transporting capacity and an elegant image of the construction on a blue (the sea) and green (the surrounding hills) background. However, the environmental organisations informed the public, and particularly the two affected towns of Messina and Villa San Giovanni, of what the bridge construction involved. This project would require tens of building sites, the occupation of natural river catchments for the temporary storage of millions of cubic metres of construction material arising from the excavations for galleries, towers and viaducts. In addition, the project would consume millions of cubic metres of water in an area that already has serious water supply problems. Other problems would include the use of an already congested road infrastructure and construction in an earthquake prone area.

Within the area affected by the construction there are 11 sites of Community Importance, two sites of special protection and a regional nature reserve. The latter, which is also a SPA and a pSCI, would be irreversibly altered: the enormous excavations for the tower piles would intercept the aquifer that feeds it, which has peculiar chemical and physical parameters due to its mixing with sea water. These parameters have allowed the presence of more than 350 animal species, 10 of which are endemic. The realisation of such a project would destroy a land and a sea of myths, legends, history, culture and nature that are unique.

Fig. 7.11 Filicudi and Alicudi islands viewed from the summit of Fossa delle Felci mountain (Salina, Aeolian islands) (Photo courtesy of A. Giordano) (*See Colour Plates*)

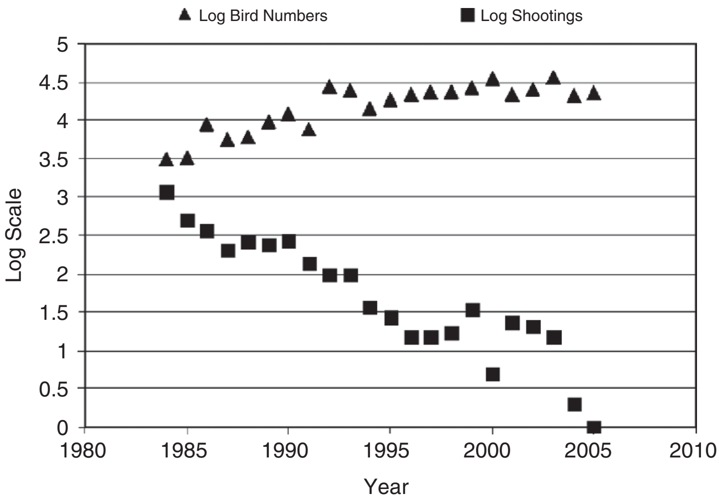

Fig. 7.12 The effects of poaching control on bird populations

SPAs due to its importance as a bottle neck for migratory birds are not respected by local and national bodies. The latter often support infrastructures that decrease the area available to migratory birds or which have the potential to create an obstacle to migration, such as the proposed project for the construction of a bridge on the Strait of Messina (Box 7.1).

In addition to the correct management of nature reserves by the Agency for State-owned Forests and Environmentalist Associations, other conservation initiatives have focussed on critical species such as Bonelli's eagle, the Griffon and Egyptian vulture through EU-funded LIFE projects and also through research and the census of species carried out by individuals, environmentalist associations and universities. These initiatives have attempted to protect reproduction sites from destruction and, when these were located within protected areas, to point out to the managing bodies the importance of these species and their location, in order to avoid any activity that could have a detrimental impact on such species.

Efforts to increase awareness, educate and divulge further information have accompanied these conservation initiatives, often in cooperation with managing and administrative bodies. However, the same Regional administration that promoted the Natura 2000 network and the creation of new protected areas has not followed these up with strict law enforcement. This failure has allowed further fragmentation of these protected areas, thus hampering any effort to create a real ecological network. Unfortunately, it is easy to destroy a particular habitat in a few days and despite hard efforts, it is not always possible to prevent the disappearance of habitats that should instead be protected or at least not compromised by inappropriate activities whose impact is often irreversible.

References

AA.VV (1987) Introduzione alla geologia della Sicilia. Convegno della Società Geologica Italiana, Università di Catania.

AA.VV (1995) Vari contributi sull'evoluzione neotettonica della Sicilia, Studi Geologici Camerti, Volume Speciale 2.

Alaimo, F. (2005) Sicilia. Fabio Orlando Editore – Palermo.

Benjamin, S. (2006). Sicily: Three Thousand Years of Human History. Steerforth Press: Hanover, NH.

Brullo, S. Minisalle, P. and Spampinato G. (1995) Considerazioni fitogeographiche sulla flora della Sicilia. Ecologia Mediterranea 21: 99–107.

Correnti, S. (1998) Guida insolita della Sicilia. Newton & Compton Editori: Roma.

Correnti, S. (2003) Storia di Sicilia come storia del popolo siciliano. Edizioni Clio: Palermo.

Corti, C., Lo Cascio, P., Masseti, M. and Pasta, S. (2002) Storia Naturale delle Isole Pelagie. L'Epos: Palermo.

Constantini, E.A.C., Urbano, F. and L'Abate G. (2004) Soil Regions of Italy (www.soilmaps.it, last accessed 20 January 2007).

Cuccioli, N. (1991) Storie, personaggi e luoghi segreti della Sicilia. Newton & Compton Editori: Roma

Davis, S.D., Heywood, V.H. and Hamilton, A.C. (eds.) (1994) Centres of Plant Diversity. WWF/ IUCN: Cambridge.

De Montmollin, B. and Strahm, W. (eds.) (2005) The top 50 Mediterranean Island Plants: Wild Plants at the Brink of Extinction, and What is Needed to Save Them. IUCN/SSC Mediterranean Islands Plant Specialist Group. IUCN: Gland, Switzerland and Cambridge, 110 pp.

Delanoë, O., De Montmollin, B. and Olivier, L. (1996) Conservation of the Mediterranean Island plants. 1. Strategy for Action. IUCN: Cambridge.

Federico, C. (2002) La Flora della Riserva Naturale di Torre Salsa. Regione Siciliana Assessorato Territorio e Ambiente.

Fornasari, L., Violani, C. and Zava, B. (1997) I Chirotteri Italiani. L'Epos: Palermo.
Giordano, A. (1991) The migration of birds of prey and stork in the Straits of Messina. Birds of Prey Bulletin n.4.
Giordano, A. (2004) Bilancio dell'esperienza del WWF Italia – Onlus nella gestione delle Riserve Naturali in Sicilia' – Naturalista Siciliano, IV, XXVIII (I): 757–767. In G. Casamento, M. Lo Valvo, B. Massa and S. Pasta (eds.) Il contributo dei Parchi e delle Riserve Naturali alla conservazione della Natura in Sicilia. 816 pp.
Giordano, A., Ricciardi, D. and Chiofalo, G. (2005) A 2005 Update of continuing efforts to protect migrating raptors and storks across the Straits of Messina (Italy). International Hawkwatcher 10: 11–15.
Iapichino, C. and Massa, B. (1989) The Birds of Sicily. British Ornithologists' Union, Checklist No. 11: Oxford.
Leighton, R. (1999) Sicily Before History. Duckworth: London.
Lo Cascio, P. and Navarra, E. (2003) Guida Naturalistica alle Isole Eolie. L'Epos: Palermo.
Mack Smith, D. (1970) Storia della Sicilia medievale e moderna. Laterza: Bari.
Ministero dell'Ambiente (2001) Relazione sullo Stato dell'Ambiente 2001. Roma.
Pirrone, G. (1994). L'isola del sole. Edizioni Electa: Milano.
Poli Marchese, E. (2003) Piante e fiori dell'Etna. Sellerio Palermo.
Pratesi, F. (1974) Guida alla natura della Sicilia. Mondadori.
Priolo, A. (1984) Variabilità in *Alectoris graeca* e descrizione di *A.g. orlandoi* subsp. Nova degli Appennini. Rivista Italiana di Ornitologia 54: 45–76.
Priolo, A. (1967) Distrutti i Grifoni delle Caronie? Rivista Italiana di Ornitologia 37: 7–11.
Priolo, A. (1970) Affinità della Coturnice *Alectoris graeca* e conseguenze dei ripopolamenti effettuati nei distretti da essa abitati ricorrendo alla Coturnice orientale *Alectoris chukar*. Rivista Italiana di Ornitologia 40: 227–231.
Priolo, A. (1979) Note sul Codibugnolo siciliano *Aegithalos caudatus siculus*, Whitaker. Gli Uccelli di Italia 4: 5–13.
Protezione Civile (2003) Relazione annuale 2003.
Regione, Sicilia (2002) Relazione sullo Stato dell'Ambiente in Sicilia 2002. Assessorato Territorio e Ambiente
Sarà, M. (1998) Mammiferi delle Isole del Mediterraneo. L'Epos: Palermo.
Scalera, R. (2003) Anfibi e rettili italiani. Elementi di tutela e conservazione. Collana Verde, 104. Corpo Forestale dello Stato. Ministero delle Politiche Agricole e Forestali: Roma.
Sereni, E. (1961) Storia del paesaggio agrario italiano. Editori Laterza: Bari.
Whitaker, J. (1901) On a new species of *Acredula* from Sicily Bulletin British Ornit. Cl.11: 51–52.
WWF Italia (1996) Le aree libere costiere. WWF: Roma.
WWF Italia (2000) Riserva Naturale Isola Bella. Pangea Edizioni: Palermo.

Chapter 8
Sardinia

G. Pungetti[1], A. Marini[2], and I.N. Vogiatzakis[3]

A view over the Giara di Gesturi to the enclosed landscape (Photo: G. Griffiths)

8.1 Introduction

Sardinia (Fig. 8.1) is the second largest island in the Mediterranean after Sicily, with a surface area of 23,833 km^2 inland, a total of 24,089 km^2 including the minor islands. Its landscape mosaic confirms a position of transition between Africa and Europe, as Sardinia is almost the same distance from the coast of both continents, and is separated from Corsica by c.10 km of sea. The island is mainly mountainous

[1] Cambridge Centre for Landscape and People and University of Cambridge, UK

[2] Department of Earth Sciences, University of Cagliari, Italy

[3] Centre for Agri-Environmental Research, University of Reading, UK

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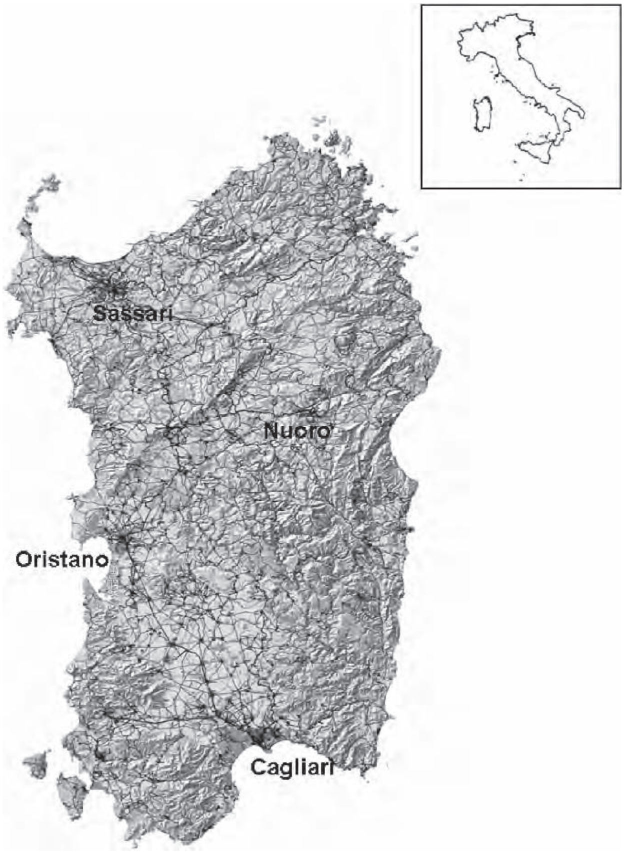

Fig. 8.1 Location map of Sardinia

with several isolated groups of mountains such as Limbara, Sette Fratelli and Gennargentu, the highest of all at 1,834 m, but also with hilly lands, plateaus and a few plains (Fig. 8.2).

The long presence of humans on the island has been of vital importance in shaping the landscape. The most ancient human remains are traced back to the Lower Palaeolithic and have been found in the North, namely in Perfugas. However, the most imposing prehistoric native culture has been the Nuragic, the remains of which are still visible today everywhere on the island, and in particularly in areas with high settlement concentration such as Campeda and Planargia. Yet, culturally and politically Sardinia has been often influenced by its neighbours. In historic times Phoenicians, Carthaginians and Romans succeeded one another as the island's 'masters'. Following the eclipse of the Roman Empire, Vandals and Byzantines held the island before it became a protectorate of Pisa, Genoa and then Spain. Finally, after a period as independent kingdom (1718–1861), Sardinia joined the unified Italy in 1861.

Although historically Sardinia was divided into four administrative provinces, i.e. Sassari, Nuoro, Oristano and Cagliari, recently four more provinces, i.e. Medio-

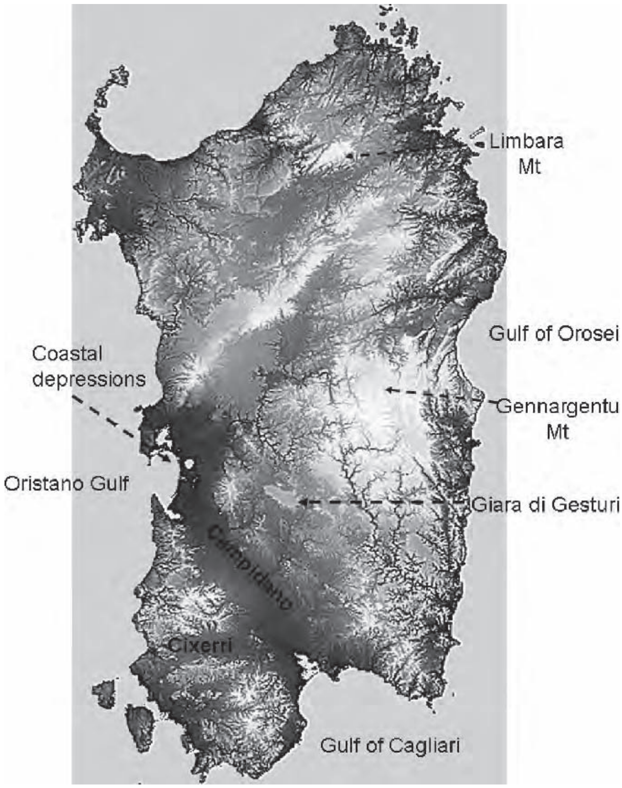

Fig. 8.2 Geomorphological map of Sardinia (see Box 8.1)

Campidano, Ogliastra, Gallura and Sulcis Iglesiente, have been added to facilitate general planning and management. This political subdivision reflects the large geomorphologic areas that characterise the island. Sardinia is with no doubt underpopulated when compared to other Italian and European regions: it has a demographic density of 66 inhabitants per km^2, compared with the average of 194 persons per km^2 for Italy (ISTAT 2001).

The complex interface between people and landscape can be traced back to the time of the Carthaginians and the Romans, when large-scale deforestation was carried out in favour of cereal cultivation. Today irrigated agriculture takes place only on the alluvial plains; it ranges from traditional vineyards and olive groves to the plastic greenhouses of market gardens and fruit gardens. The extent of pastures has recently increased together with the practice of dry seeding to improve them.

Nevertheless, Sardinia still retains a natural environment which has been relatively well preserved. Landscape diversity results in habitats which range from lagoons and vegetated sand dunes in the coasts, to extensive maquis and forests in the mountains. Historical events are reflected in shifts of people and settlements. During the course of history, for instance, invasions by outsiders caused abandonment of coastal areas and the concentration in the mountainous interior. Part of the population, conversely, moved with times from the mountains to settle down on hilly and flat pastoral land, forming isolated homestead settlements.

In recent decades, the inland mountain villages have continued to lose population, while the largest towns have expanded due to economic development. Lowland plains and coastal zones have also grown rapidly due to agricultural and tourist development respectively. This is indeed a common trend in the Mediterranean Islands, which has caused relevant changes in their landscapes, and Sardinia is no exception. These trends and changes are described in the following sections of this chapter.

8.2 Physical Environment

8.2.1 Climate

The climate of Sardinia is biseasonal with warm, arid summers alternating with cold, humid winters typical of the Mediterranean area. The position of the island between the temperate and the Subtropical zone, and the strong influence of sea breezes, are the main climate determinants.

There are annual variations with summer storms, which differ from the average distribution of rain that usually occurs in spring and autumn. The sea around the island mitigates the cold that the northern wind carries during the winter as well as the summer heat, with breeze that at the sunset moves towards the land. The correlation of the phenomena that regulate the climate, as the rain and change of the coastal stream during the season, is a source of variability for Sardinian climate, which is exposed to those two determining factors of climate equilibrium. Consequently a feature of the climate is the alternation of strong wind with unforeseen rain.

Sardinia benefits from a series of microclimates too. Those are related to the different influence of the coast, the degree of exposure to the sun and the protection from the dominant winds of the inner areas. The central mountain area is in itself a source of climate variation because in winter it can be covered by snow for some days, while in the summer the breeze that descends along the valleys mitigates the heat of the coasts.

The distance from the European continent and the relative proximity to Africa confers a specificity of climate, which has diverse bioclimatic parameters. The wind regime is shaped by orographic features, which gather the air coming from different directions (Table 8.1). Mistral is the dominant wind, which is guided towards the lowland of Cagliari, along the tectonic valley of Campidano. Wind and waves concern mainly the western coast, more frequently affected by long storms. The northern coast, inserted in the 'Bocche di Bonifacio', is known for the summer winds and variable sea conditions, which make it an ideal training site for sailing schools.

Table 8.1 Principal winds in Sardinia (From Chessa and Delitalia 1997)

Name	Direction of origin	Intensity
Tramontana	North	Low
Grecale	North-east	Low
Levante	East	Medium
Scirocco	South-east	Medium
Ostro	South	Medium
Libeccio	South-west	High
Ponente	West	High
Maestrale (Mistral)	North-west	High

8.2.2 Geology and Soils

The variety of the landscapes that characterize the island of Sardinia is strongly linked to the geological history of the island from Precambrian until today. This complexity is demonstrated by the irregular distribution of numerous lithologies outcropping in the island.

During the Palaeozoic the basement structure was defined by the early Caledonian and the Hercynian orogeny. This structure consists mainly of granitic metamorphic rocks, covering about a third of the island in eroded medium relief landscape. The erosion of the Palaeozoic resulted in a low relief landscape which was repeatedly invaded by the sea during the Mesozoic. The outcrops of limestone and dolomite, which appear in the central east and northwest coast (sometimes more than 800 m in thickness), are proof of a substantial marine transgression.

During the Tertiary, the Alpine orogeny delineated the actual configuration and the structural arrangement of the island (Marini et al. 2001). A complex system of semi-rift was created along a north-south axis and affects the whole of Sardinia. This system is linked to the convergence of Africa and Europe, and is accompanied by a first alkaline volcanic cycle caused by the movement towards the southeast of the Sardinian–Corsican complex, which separates Africa from the European super continent and it displaced Sardinia to its present position. A second basaltic volcanic cycle ended less than 60,000 years ago. The associated lava flows filled the wide and shallow valleys of the time and helped preserve their features, now characterizing the landscape with plateaus that provide the evidence of high erosion rates. These important movements of uplifting gave way to a strong erosion that determined the isolation in reversal of the basaltic relief, resulting in extended high plateau having the characteristic profiles and called *giare*, e.g. in Gesturi and Serri.

Sardinia was one on the most important mining regions in Italy. As early as the Phoenician and Roman periods, extensive areas of the island such as Masua, Inglesias, Marganai and Fluminimaggiore were mined for barite, fluorite, silver and lead. At present all but one, i.e. Silius, are shut down and replaced by industrial archaeology sites. Only a new gold mine has recently been opened in Campidano.

The soils dominating the island are of low to medium depth, medium organic matter content, and high erodibility. Deep soils of moderate erodibility are predominantly used for agricultural purposes (Table 8.2).

Table 8.2 Dominant soil types in Sardinia (Aru et al. 1991)

Soil type	Substrate	Land use	Location
Typic, Dystric & Lithic Xerorthents	Palaeozoic metamorphic rocks	Pasture, wooded pasture	Ogliastra, Barbagia, Inglesiente
Typic, Dystric & Lithic Xerorthents	Palaeozoic Intrusive rocks	Pasture	Gallura, Barbagia, Sarrabus
Typic, Aquic & Ultic Palexeralfs	Alluvial and arenaria	Agriculture	Campidano, Cixerri, Ottana, Nurra

Fig. 8.3 The elongated ridges of the mountains are connected on the highest top of Sardinia: the Gennargentu. The name means Silver Mountain, because snow is visible from the sea till advanced springtime (Photo courtesy of AERONIKE) (*See Colour Plates*)

8.2.3. Geomorphology

Three main geomorphological sectors can be identified in the island (Fig. 8.2). The eastern sector has the most important relief and includes the Limbara and Gennargentu mountains (Fig. 8.3). The central longitudinal territories are characterized by the wide basaltic lava flow from the big pluvial plane and the undulated Miocenic hills. Finally, the Palaeozoic relief of the West constituted by the coastal relief of Nurra and in the South by the Iglesiente and Sulcis reliefs (see Box 8.1).

The most important rivers, as Coghinas, Tirso and Flumendosa, subdivide these three sectors along tectonic fractures with deep erosions related to the Pliocenic uplifts. Rivers have generally a torrential course, due to the geological structure of the island terrain, with dry summers and scarcity of rainfall. Sardinia has only one natural lake, namely Baratz near Alghero, but presents a large number of coastal lagoons, some of which have been drained and transformed into fertile agricultural land, while others are still being used for tourism, fishing and salt production (Fig. 8.4).

Fig. 8.4 The Tortoli pool is one of the coastal lagoons used for fish farming. The origin of this depression is connected with the deep quaternary erosion during the glacial periods. The depression was not completely filled due to the protection of the coastal hills and the absence of important rivers (Photo courtesy of AERONIKE) (*See Colour Plates*)

Box 8.1 A Geomorphological Map of Sardinia Obtained from a D.E.M.

Digital Image Analysis combined with Digital Elevation Models (DEMs) facilitates insights into landscape evolution. Using these techniques a geomorphological map of Sardinia was constructed (Fig. 8.2) facilitating the identification and interpretation of phenomena and features that in the past have been elusive. One example is the Campidano Plain that connects the gulfs of Cagliari and Oristano tied to a tectonic origin of Plio-Quaternary age. Near the gulfs there are coastal depressions forming wetlands, or reclaimed for agriculture (shown in white in Fig. 8.2). These depressions result from erosion that occurred during the glacial periods when sea level was 120 m below the present level. The seashore at that time was found at the edge of the continental platform and the rivers became incised in areas that now form the current coastline. The seismic profiles show incisions of up to 70 m deep. More significant erosion has occurred on the whole island caused by tectonic uplift during the Pliocene. This tectonic movement raised the land surface to various elevations above sea level including those surfaces composed of marly and calcarenitic Miocene sediments, which formed a landscape characterized by wide fluvial valleys that now have all but disappeared due to erosion. The forms were preserved by the lava flows that filled up the depressions when the compressive tectonic phase connected with the uplifting was replaced by a phase that allowed the opening of the fractures and the exit of magma, leading to the formation of the *Giare*. The most famous giara, the Giara of Gesturi is distinguished by the homogeneous clear tones and an arrowhead shape (Fig 8.2). The flat basaltic surface is surrounded by a high cliff that corresponds to the lava thickness, and then by an escarpment of c.400 m high that is cut on the Miocenic layers. Similar differences in elevation occur in the deep valleys where the main rivers are often characterized by incised meanders, a reminder of their forms prior to the uplift and the resultant erosive phases (Fig. 8.5). Another wide sector, visible in Fig. 8.2, is characterized by medium-grey tones and homogeneous pattern, and corresponds to other lava flows. The sector located in the middle of the island is divided in two levels, marked by different tones that correspond to c.3.5 million years for the northern and 1.5 million years for the southern sector. The edge of these flows is also deeply marked by the total removal of the rocks that might have formed the lateral continuation of the valleys occupied by basalts. Relief inversion is obvious where, what once filled up the bottom of a valley, now is the backbone of a plateau (Fig. 8.6). Fig. 8.2 shows a clear difference between the northern and southern sectors of the island, with a separation along diagonal lines across the whole island. These lines follow another ancient line that cut the metamorphic Palaeozoic rocks and the granites, characterizing the Sardinian landscapes. Along these lines and other similar discontinuities, watercourses become deeply incised. Other tectonic valleys are also evident, e.g. in Cixerri. Isostatic uplifting coupled with deep erosion as sea level fell, removed outcrops of Pliocene rocks. The eroded sediment, with identifying fossils, has infilled the tectonic graben of the Campidano. Erosion regimes persist in the island today and the resulting deep valleys offer hence no land for agriculture. Only at the mouth of the biggest rivers large coastal plains have been formed, now developed with orchards and tourist resources.

Fig. 8.5 The Gorropu gorge, with 200 m of vertical walls, is cut from the Flumineddu river. In front it is possible to see the calcareous block open to the Tyrrhenian Sea with 400 m cliffs of the Orosei Gulf (Photo courtesy of AERONIKE)

Sea level variation linked to the different phases of the Quaternary, consisting in a regression of up to 120 m below the present sea level, has contributed to the erosion and weathering of all the mountain flanks, with a direct impact on their steepness. These incisions are strictly marked by lines of interglacial alluvial terraces, which are present along the coasts.

In places where the draining material from the mountains has been deposited, relatively wide plains have been formed, as Coghinas in the North, Tirso in the Gulf of Oristano, and the plains of Rio Picocca, of Flumendosa, of Cedrino and of Taloro in the eastern coast. In the southern area and in the Archipelagos of La Maddalena, the evolution during the regression had not been balanced by the following accumulation of stone and soil, and the coastal landscape is hence still characterized by the coast *a Rias*, where the sea occupies the fluvial palaeo-valleys.

Fig. 8.6 This flat valley near the village of Isili (Central Sardinia), is now occupied by the water of an artificial lake, with the old church on a small island. It is easy to identify an elongated hill formed by the hard volcanic rocks that preserved the more erodible calcareous rocks, with an evident example of relief inversion (Photo courtesy of AERONIKE) (*See Colour Plates*)

During the Tertiary the tectonic movements of the late Alpine orogeny have determined the final structural aspects. In this period the most important geographic transformations and the conformation of the Mediterranean basin took place. These transformations are clearly over the big lineaments of the Hercynian orogeny, developed in a completely different paleogeography. The raising of the Mesozoic carbonate covers to different levels started their dismemberment and also caused regressive erosions. The residual borders of these covers are recognizable in the isolated relieves called *Tacchi*, with rectilinear edges and high vertical walls, recorded in deep canyons. The centre-eastern Sardinia in Barbagia of Seulo is an example of these features. In these zones the residual shapes of the relief traces the evolution of the paleogeographic changes: their careful examination provides therefore insights for the reconstruction of the several transformations of the landscape.

8.3 Biotic Elements

8.3.1 Flora

The palaeogeographic history of Sardinia is inextricably linked with that of Corsica, and although this has been a subject of debate among biologists, geographers and palaeontologists (see Cordona and Contadriopoulos 1979) it is now widely accepted that the two islands formed the Cyrno-Sardinian microcontinent which fragmented and migrated in the Oligocene and Miocene (Chapters 2 and 10). Therefore the majority of biotic affinities of Sardinia are with the island of Corsica (see also Chapter 10). This is particularly reflected in the island's endemic flora where species have distributions that encompass the different parts of this microcontinent (Thompson 2005).

The island's flora comprises about 2,054 species, c.200 of which are endemic (Bocchieri 1995). These are either species of recent formation, or in the phase of evolution, or of ancient origin, i.e. palaoendemics. The latter include *Soleirolia soleiorolii* and *Nananthea perpusilla*, but also *Centaurea horrida* a 'living fossil' that has been present on the island long before the appearance of dinosaurs on Earth (Chiappini 1985).

Therophytes constitute 39.9% of Sardinian flora followed by hemicrypto-phytes (28.1%) and geophytes (12.1%) (Bocchieri 1995). The dominance of the therophytic element in the flora (Table 8.3), one of the highest in Italy, is due to long human influence but also to the cyclical marine regressions during the Messinian crisis that exposed and concealed new niches for species. There is a substantial number of exotic species, c.900 (Delanoë et al. 1996) which includes introductions from South Africa (e.g. *Cotula coronopifolia*), tropical America (e.g. *Heteranthera limosa*) and global weeds such as *Ammania auriculata var arenaria, Elatine triandra* and *Cyperus glaber*. Other notable elements in Sardinia's flora are the populations of *Laurus nobilis*, relicts of Laurisilva forest, and the presence of yew (*Taxus baccata*) and holly (*Ilex aquifolium*) species belonging to the Eurasiatic flora of pre-Miocene origin that now occupy a limited range in the Mediterranean Basin.

Table 8.3 Life form spectrum of the Sardinian flora (Bocchieri 1995)

Life form	Species number	Percentage
Phanerophytes	179	8.8
Chamaephytes	168	8.1
Hemi-cryptophytes	577	28.1
Geophytes	248	12.1
Therophytes	821	39.9
Hydrophytes	63	3
Total	2.054	100

The Corso-Sardinian orophile endemics show affinities with those of the central and southern European mountains, which suggest the existence of an ancient mountain system at the beginning of the Tertiary linking the Cyrno-Sardinian massif with the mountains of Europe (Cardona and Contadriopoulos 1979). Above the tree line there is presence of dwarf shrubs such as *Astragalus genargenteu* representing Irano-Turanian and Saharo-Arabian elements, as part of the Arcto-Tertiary flora that came into the Mediterranean Basin 5.6–5.3 million years ago.

According to Delanoë et al (1996), 3% of the island's flora belongs to globally threatened taxa, while 8% of the total taxa are locally threatened (see Table 4.5). Among the most threatened endemic species on the island are *Aquilegia barbaricina, Aquilegia nuragica, Lamyropsis microcephala, Polygala sinisica* and *Ribes sardoum* (De Montmollin and Strahm 2005).

8.3.2 Vegetation

Over two thirds of the island are covered by semi-natural vegetation typical of the Mediterranean region (Fig. 8.7). The principal formations include forests of holm oak (*Quercus ilex*), cork oak (*Quercus suber*), broadleaved downy oak (*Quercus pubescens*), aleppo pine (*Pinus halepensis*) and maritime pine (*Pinus pinaster*), as well as chestnuts (*Castanea sativa*), maquis and garrigue (Barneschi 1988; Chiappini 1985). Maquis are the most characteristic of the vegetation mantle. Mainly dominating the rocky slopes, they comprise wild olive (*Olea europaea subsp. sylvestris*), lentisk (*Pistacia lentiscus*) together with junipers, myrtle (*Myrtus

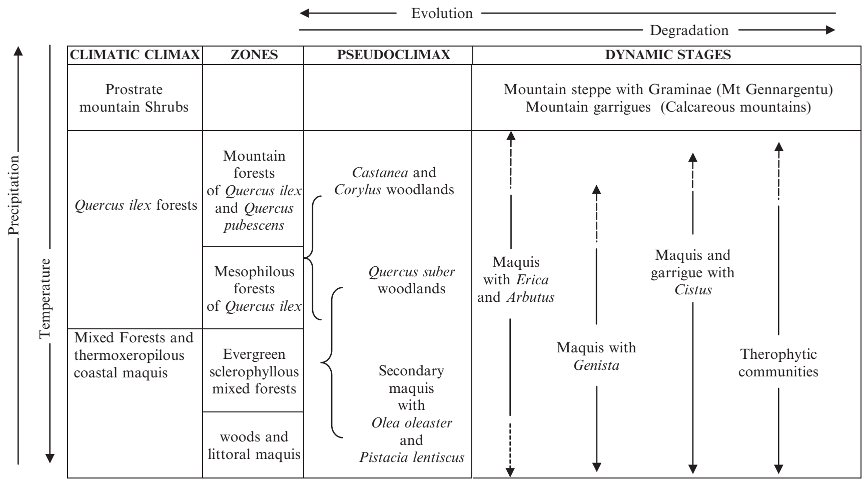

Fig. 8.7 Schematic diagram of the climatic climax and the principal dynamic stages involved in vegetation succession in Sardinia (Modified from Arrigoni 1968, reproduced with permission from Webbia)

communis) and strawberry trees (*Arbutus unedo*). The mountains of Sulcis, in the southeast of Sardinia, retain extensive areas of maquis.

A unique characteristic of the island's vegetation is the extensive cork oak forests with an estimated area of 90,000 ha. This figure increases significantly to a total surface area of 200,000 ha, if wooded pastures are included (Boni 1994). These habitats are concentrated in the areas of Gallura, Iglesiente, Mandrolisai, Giara of Gesturi, Goceano, Planargia and the high planes of Buddusò, Alà, Bitti and Orune. Close to areas of intensive agricultural activities wooded pastures that may extend to the foothills of mountains are abundant. In these habitats *Quercus suber* is usually the dominant species or in mixture with *Quercus ilex, Quercus pubescens* and *Olea europea*. Mixed or pure oak forests can be found in the mountains such as Limbara in the North and mountain Linas in the Southwest, while *Taxus baccata* and *Ilex aquifolium* formations are present in mountainous areas over 700 m (Chiappini 1985). At c.800 m is the upper limit of deciduous trees and bushes, whereas higher altitudes are the domains of the coniferous forests. Above the tree line cushion formations with prostrate shrub species such as *Genista salzmanii, Astragalus sirinicus, Juniperus communis* subsp *nana, Prunus prostrata, and Rhamnus persicifolia* dominate.

Sardinia still retains probably the most extensive dune systems (Mayer 1995) compared to other Mediterranean Islands. These systems support formations *of Juniperus oxycedrus* subsp. *macrocarpa* at Scivu, Piscinas and Genna Armidas (Todde 2002) which are unique for the endemic species they host and therefore are protected under the European Habitat Directive (Council of Europe 1992). A peculiarity of the island is the coastal lagoons with wide surfaces of low-depth water, surrounded by *Juncus* and *Typha*, but also by *Tamarix* and *Salix* sp. The riparian flora marks many rivers and torrents of Sardinia with oleanders, alders and poplars. The coastal vegetation is low garrigue shaped by the wind, with cushion shaped lentisks, euphorbias, phillyreas and the dwarf palm (*Chamaerops humilis*).

8.3.3 Fauna

The mammals on the island include fox (*Vulpes vulpes*), wildcat (*Felis sylvestris*), marten (*Martes martes*) and wild boar (*Sus scrofa*). The latter is widespread, although bigger exemplars have been introduced from Tuscany in the last century. The fallow deer (*Dama dama*) is also a recent introduction. The deer (*Cervus elaphus*), which during the prehistoric period used to live in the whole island from the hinterland to the coastal zone, is now confined to the mountainous areas. On the mountains and in particular on high calcareous cliffs, mouflons (*Ovis musimon* or *Ovis ammon musimon*) are living in small groups consisting of one male and many females. Wild horses can be found on the plateau of the Giara of Gesturi. These are smaller than domestic horses and their origin is uncertain. They were probably imported from the Far East, and have lived on the plateau from time immemorial. Another peculiar element of Sardinian fauna is the white donkey found at the island of Asinara north of the Sardinian coast. A descendant of the species originally native to Egypt, they were introduced to the island and have adapted to the local conditions over the times.

The island has an important avifauna that merits conservation including griffon vultures, *Haliaeetus albicilla, Falco eleonorae*, black-winged stilt (*Himantopus himantopus*) and the yellow-legged gull (*Larus michahellis*). Lagoons in particular are among the most important ornithological habitats on the island since they host a variety of wetland species including spoonbills, cranes, avocets, cattle egrets and cormorants. Although flamingos have long used these lagoons as a stopover on their migration from Africa to the Camargue in France, recently they have started nesting and breeding there. The largest colony is found on the lagoon of Molentargius, completely surrounded by the suburbs of Cagliari.

Sardinia counts various endemic animal species, including the Sardinian newt (*Euproctus platycephalus*) (Lecis and Norris 2004) the dormouse (*Myoxus glis Melonii*) and the Sardinian salamander (*Speleomantes genei*).

8.4 Cultural Landscapes

8.4.1 Ancient Times and Middle Ages

As with other Mediterranean areas (Meeus et al. 1988), Sardinia has undergone a transformation from the wilderness of the original Mediterranean forest to an agricultural landscape with wheat fields in the plains, vineyards on the slopes, and pastoral land in the highlands. Contacts with the eastern Mediterranean first (before 500 BC), and the Carthaginian occupation later (509–238 BC), developed external trade with an increasing demand for timber, building material and livestock. This initiated natural resources exploitation, with consequent deforestation for agricultural and pastoral land. In addition mines and quarries were initiated (Barreca 1974). A further modification appeared during the Roman period, when the cultivation of cereals and a few vineyards (Meloni 1975) were developed using Roman agricultural and *centuriation* techniques.

After the fall of the Roman Empire (238 BC–456 AD), the occupation by the Vandals and the Byzantines left the island in a state of decay. Moreover, the first Moslem incursions (7th–10th century) led to the abandonment of the coast and the depopulation of the inner centres. The effect was a return to a semi-natural state: many agricultural fields were covered with bushes and woods, and the Mediterranean maquis returned in the lower areas.

In order to defend Sardinia from the Moslems, in the early Middle Ages (900–1420) four *giudici* were appointed, as both military and religious leaders. They had the power to assign land to people with no property for agriculture and animal breeding. Hence rapidly sheep farming spread, setting the basis for a pastoral culture which continues to dominate the island over arable agriculture (Pungetti 1996a).

This is the period where the subdivision of the rural territory into plains and mountains due to the diverse social composition was already evident (Fig. 8.8). The

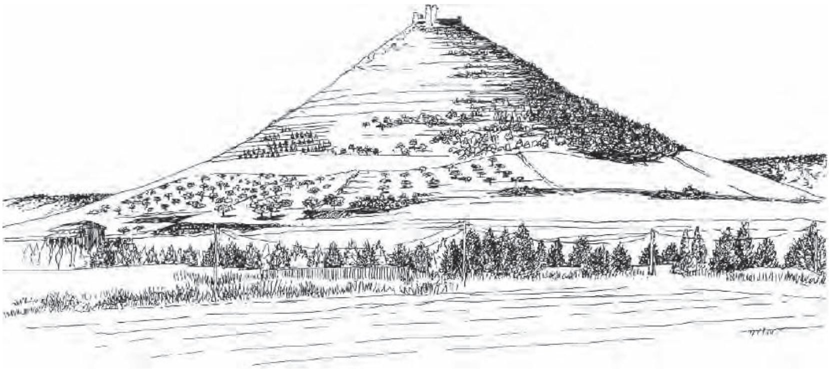

Fig. 8.8 The cultural landscape in Sardinia (La Plassas) showing the coexistence and persistence of human and natural aspects in the Mediterranean

plains were settled by peasants and citizens, while the mountains were dominated by shepherds closer to ancestral traditions (Boscolo 1978). The Sardinian agricultural landscape was characterized by open lands, called first *pauperile* and later *paberile*, and enclosed lands called *cunjadus*. The first group was mainly cultivated with cereals, while the second group was mainly planted with vineyards and sometimes orchards (Fig. 8.9). Sardinian agrarian products attracted many outsiders, influencing the island economy, society and land use, with important repercussions for the landscape (Pungetti 1995). From the 13th century, for instance, the continuous contacts with the sea-faring republics of Genoa and Pisa increased trade and affected the demand for timber. Consequently, forests were exploited and repopulation of coastal centres began. At the end of the Middle Ages, economic problems and a preference for wheat monoculture produced a decline in Sardinian agriculture, with subsequent decay of the cultural landscape.

8.4.2 The House of Savoy

When the Savoy dynasty took over the island in the 18th century, it realized the necessity for an incisive transformation. Experts in the advanced techniques used in Piedmont, they opted for a shift in agriculture in order to overcome the problems resulting from the practices of the Middle Ages (Da Passano 1982). The House of Savoy started some reclamation work, aimed at reducing malaria and preventing the regeneration of marshes. Their desire to bring Sardinia into a capitalist structure was pursued through two strategies: (a) a shift towards arable agriculture over sheep farming and (b) the linking of land property to land use (Scaraffia 1984). Landscapes were transformed as fields were converted from forestry and pasture to cultivation, and from enclosed wood and pastoral land to open agricultural land. New cultivation systems, moreover, led to landscape innovations and new field patterns (see Pungetti 1996a).

Fig. 8.9 The countryside of Nuragus is cut on the Miocenic arenaceous limestones. Orchards and vineyards are filling the valleys in small fields normally cultivated by a single farmer; the top of the flat hills are used for dry pasture (Photo courtesy of AERONIKE) (*See Colour Plates*)

Furthermore, the royal edict of the *chiudende* (fences) allowed for the enclosure of communal land and the consequent demarcation of individual ownership of property. Small farmers, however, were unable to fence large areas and therefore the privatization of the land favoured the upper class. To add to this, the charge for pasturage reinforced the clash between shepherds and peasants. The former, after a substantial reduction of pastoral lands, destroyed many of the fences and appealed to the Royal Government. As a result, in 1835 the Savoy administration ordered, with a direct act, the suspension of the edict, forbade the rebuilding of the destroyed fences and permitted the demolition of those fences damaging the shepherds' livelihood. The *chiudende* had great impact on the Sardinian landscape, as previously open lands became enclosed lands. Many fields were fenced with ditches or walls, according to the morphology of the area: in the plains, for instance, shrubs and prickly pear were used, while in the mountains stone walls prevailed.

In the middle of the 19th century, due to the failure of governmental development programs, the Sardinian agricultural situation was critical. Only a few areas like the estate of Villahermosa in the South (Casalis 1833) reflected the agricultural ideals of the House of Savoy. At the end of the 19th century, political events and lack of agricultural skills contributed to the deterioration of the social framework, still based on family clans. Shepherds began to resent farmers, often leading to deforestation and damage of agricultural properties (Makhzoumi and Pungetti 1999).

8.4.3 Agrosilvopastoral Landscapes

Many state interventions attempted to develop the agrarian economy of Sardinia after World War I. Malaria eradication, river control and irrigation allowed previously underutilized lands to be transformed into intensively cultivated lands. Agricultural development was also one of the goals of the fascist dictatorship (1922–1940), which conducted initiatives such as public works and reclamation schemes (Seghetti 1928). This brought about further changes to the Sardinian landscape, with new drainage channels for land reclamation and the disturbance of wetland ecosystems.

The scattering on the island of wooded pastures, characterized by the dispersion of chestnuts, cork oaks and holm oaks, has given rise to a distinct cultural landscape (Fig. 8.10). These landscapes, retaining both ecological and economic significance, are indeed a common characteristic of many Mediterranean countries (Pungetti 1996b; Grove and Rackham 2001). Ecologically, they host diverse animal and plant communities with many endangered species, and therefore are currently preserved in the protected areas of the island (Vogiatzakis et al. 2005). Economically, they

Fig. 8.10 Agro-silvo-pastoral landscapes in North Sardinia dominated by cork oak (Photo courtesy of I. Vogiatzakis) (*See Colour Plates*)

provide direct benefits derived from cork exploitation and parallel activities carried out under cork canopies, e.g. cropping and grazing, which are of considerable social importance. They are in fact associated with traditional agrosilvopastoral practices in Less-Favoured Areas of the European Community, where other sources of income and employment are limited (Commission of the European Communities 1997).

These traditional agrosilvopastoral systems, although relatively new since they developed during the 19th and 20th century, represent a sustainable balance between human activities and natural resources. In the words of Naveh and Lieberman (1994) these agrosilvopastoral systems are *the result of management practices optimising the typical annual fluctuations in productivity without causing ecological degradation*. These practices, creating landscapes of high heterogeneity and cultural value, provide evidence of the important contribution to the maintenance of valued semi-natural habitats and landscapes in Europe (Council of Europe 1992; Council of Europe, UNEP and ECNC 1996).

8.5 Recent Environmental Changes

8.5.1 Landscape, Rural and Cultural Changes

Until World War II the two main economic activities of Sardinia were sheep rearing and mining. During the 1950s, with the use of imported oil for industrialization, this pattern changed. However, much of the development in the island in the period between 1955 and 1975 was only modernization rather than real economic development (King 1975).

After World War II, Sardinian agricultural production was partly mechanized but, having been slow to adopt new techniques and new cultures, the Sardinian market was not able to withstand the competition from other countries. Today, Sardinia produces a great variety of Mediterranean crops, the most important of which are wheat in the open lands, vineyards and olives in the enclosed lands and artichokes in the orchards. The subdivision of cultivated areas into smaller parcels due to inheritance, brought about many changes in landscape patterns (Fig. 8.11). In addition, the spread of greenhouses and quarry activity introduced new elements, which had a strong visual and ecological impact on the landscape (see Pungetti 1995).

Despite the fact that agricultural production was partly mechanized, Sardinia still lagged behind the other Italian regions and its unit yields per hectare are the lowest in Italy. Three quarters of the Sardinian forest were destroyed in the 19th century by exploitation from mainland Italy, using timber for railway sleepers and pit props. The present woodland area of about 300,000 ha plus a great extent of maquis is of little economic importance, with cork as the most considerable product. The cork industry, which flourished in the beginning of the 19th century, is currently in decline (Ruju 2002) while there are concerns about the use of plastic cork stoppers and the threat this may pose in the long term to economic and ecological stability (Goncalves 2000).

Fig. 8.11 Anonymous manuscript of the 18th century, a useful tool in the reconstruction of the landscape of Cagliari and the surroundings. After Pilon 1974, plate CXLVII (Reproduced with permission of Edizioni della Torre)

Livestock products, unlike in other parts of southern Italy, occupy a relevant place in the economy, having represented in the 1970s more than half of the island's agricultural production. The *pascolo brado*, a semi-wild system of livestock farming, was the most widespread practice of past times. Nowadays, while sheep are still the strength of livestock farming, goats are also significant due to the diversification into the production of goat cheese. Fishing, remarkably, seems never to have been one of the principal activities of the Sardinians, despite the good supply of quality fish in the surrounding sea.

The present lowland landscape of Sardinia is unfortunately under threat from excessive use of pesticides, agricultural mechanization, salt intrusion and desertification (Aru et al. 1991; Pungetti 2001). In addition, the absorption of the land by recent urban spread and industrial activity has further damaged the island landscape (Leontidou et al. 1997).

Tourism is one of the most important economic sectors of Sardinia, having grown considerably in the post-war period. However, most of the tourist development has been left in foreign hands. This shows again that Sardinia has been an exploited land rather than a region of enterprise (Makhzoumi and Pungetti 1999). Moreover, due to the pre-eminence of natural over cultural resources, Sardinian tourism has a seasonal (summertime) and local (coastal) character. Yet recent improvements, like the creation of national parks and protected areas, are contributing to a new configuration of the tourist industry, closer to culture and nature and increasingly concerned about the environment.

Whilst identification of the Sardinian civilization with a mountain society can today be considered passé, a strong regional identity is still present. The latter, added to a nationalistic resistance, did allow little continental influence and supported instead autonomous Sardinian aspirations. These are among the reasons that induced the Italian Constituent Assembly, after World War II, to declare Sardinia an Autonomous Region with a Special Statute (*Regione Autonoma a Statuto Speciale*).

Sardinia's unique history is linked not only to its insularity, but also to the way in which its social elements are organized. Within this context, the landscape itself is another element which reveals Sardinia as a 'land of contrasts' (Pungetti 1996a). Shepherds with their flock near oil-refining industries, flamingos flying over the lagoon surrounded by multi-storey buildings in Cagliari, modern tourist resorts next to vernacular buildings, traditional festivals and modern internet industry, elderly wearing ancient costumes daily and walking close to youth with trendy outfits, are just a few contrasting images. The further distinction, significantly, is that external developments can occur without causing a loss of identity within the Sardinian society. Regional identity, indeed, is here not just a tourist fiction but a reality.

8.5.2 Changes in Land Use and Landscape

In parallel with the recent trends in southern Europe, the agrosilvopastoral landscapes of Sardinia have undergone irreversible deterioration through intensification, extensification and land abandonment. Long-term studies in north-eastern Sardinia (D'Angelo et al. 2001) show that the period 1955–1996 was marked by an increase in improved pastures at the expense of cork woodlands. Usually the removal of forest to make pasture has been followed by cultivation and subsequently by abandonment. With few exceptions, such as the area of Gallura where cattle grazing is still practised (Pampiro et al. 1991), sheep grazing has taken over and intensified since the 1950s (Mori 1972). Sheep grazing is reported as more damaging to cork woodland than cattle grazing but both are equally damaging for cork oak regeneration (Ruiu et al. 1995; Pampiro et al. 1991). As a result of the EU Common Agricultural Policy (CAP) in the 1980s, subsidies were linked to the number of animals and this contributed to a general increase in their numbers. Traditional agro-pastoral activities, moreover, have been replaced by contemporary intensive agro-industrial practices. In recent decades, for instance, the introduction of mechanized farming has led to deep ploughing of extensive areas that have never been subject to intense agriculture in the past. This results in loss of the shrub layer and a loss of organic matter, causing soil exposure and erosion particularly on steep slopes.

Grazing, which in some cases is accompanied by fire, is the major human impact. The presence of increasing numbers of domestic animals in the forest usually results in a deterioration of the forest resources, especially when accompanied by cultivation of forage species. Soil compaction, reduction of water infiltration capacity, increased run-off and sheet erosion are some of the consequences. Comparative studies between different land uses in Sardinia (Vacca 2000) have demonstrated that cork oak forests have well developed soil horizons with high organic matter, whereas in habitats of silvopastoral use soils are poorly developed with low organic matter, except for some sporadic areas under the cork oak canopy. Although nutrient content appears to be higher in the latter, this is attributed to higher supply of grazing animal excreta. As in most Mediterranean areas, also in Sardinia fire has played a significant role in the shaping of the landscape. Fires are another key issue for the island landscape successions. It has been argued that by 1970 one third of Sardinia has been under fire attacks (Ruju 2002), while official statistics suggested that between 1950 and 1985 the area burnt has increased tenfold (Grove and Rackham 2001). These changes have resulted in turn in habitat loss, damage of landscape heterogeneity, and subsequent decrease in plant and animal diversity.

8.6 Landscape Conservation

8.6.1 Landscape and Protected Areas

In Sardinia the debate on areas of particular natural importance started with the IUCN meeting in Copenhagen in 1956 and continued in the 1960s. During the 1970s, a few studies identified a variety of Sardinian biotopes of exceptional ecological value (Camarda and Cossu 1988). These studies have supported, at the beginning of the eighties, the outline of the *Management Project for Three Large Biotopes* (Sarrabus-Gerrei-Settefratelli, Sulcis, Gennargentu) by the Councillorship for the Environmental Protection. Moreover, in *Project 80* of 1969 on natural areas of national importance by the Ministry of Economic Planning, eight Sardinian areas appeared. Furthermore, the *Ramsar Convention* of 1971 provided for the protection of three Sardinian wetlands, extended in 1976 to nine. All these studies have provided the first foundation for one of the most relevant pieces of legislation on Sardinian nature and landscape protection, the Regional Law on Parks (L.R. 31/89).

It was actually in the 1970s that a system of Sardinian parks was envisaged. A methodology based on environmental protection through various territorial systems was identified taking into account scientific, cultural, tourist and economic development. In particular the system of parks, divided into nature parks, nature reserves, nature monuments and areas of natural or environmental importance, outlined three main phases: zoning, founding and management of the park (Pungetti 1996a). The Park Plan moreover was aimed to coordinate the various existing plans, with consequent impact on strategic planning at various governmental levels. Therefore the system of parks was perceived as an instrument not only for nature conservation, but also for physical planning, laying down a second foundation for the Regional

Law on Parks mentioned before. The third step was the *Pluriannual Programme for Forestry of the Regional Council of 1980*, which took into account nature oases, biotopes and parks, together with the practice of forestry and the conservation of the woodland heritage. Delimitation of the areas to protect, and regulation of the finances and management of the parks, were included.

Consequently, the L.R. 31/89 followed to regulate the management of nature parks, reserves, monuments and areas of special natural and environmental value. Its main goal was the restoration and development of the Sardinian natural heritage, identifying the parameters of possible socio-economic progress through a policy of restoring the balance between 'strong' and 'weak' areas. Three basic stages were taken for the implementation of this law: the formation of management plans for the natural parks, the drawing up of plans for a new coastal structure, and the study of a new procedure for identifying and setting up the nature monuments. Table 8.4 summarises the protected areas on the island, including the sites designated recently as part of the Natura 2000 European Network (Fig. 8.12).

Another relevant Sardinian piece of legislation is the Regional Town Planning Law (L.R. 45/89), which refers to nature conservation in the protection of the coastal strip within 2 km from the sea, divided into two areas. In the first, within 500 m from the sea only works of urbanization, public service and overriding public interest are allowed, subject to permission. In the second, between 500 and 2,000 m from the sea, permission is granted for intervention of an agrosilvopastoral character, on environmental protection and public health, public interventions and those for implementing plans to improve and reconstruct houses. In this second strip, however, 'exceptions' were allowed (see Pungetti 1996a). Moreover, the law was not fully restrictive since it further provided for 'permission' by the mayor, subject to authorization at the highest levels, for particular works. Furthermore, the slowness of the approval procedures of the Territorial Landscape Plans and the Law on Parks, together with the around 240 permissions granted by the Region for new hotel structures along the coasts, aggravated the already critical situation (Stancampiano and Deliperi 1993).

The paradox is that in 2006, 17 years after the two regional laws mentioned above, the Berlusconi government proposed a national act, hence more enforced than the other two, that could have allowed the State to sell public area of coastal land to external private companies for the development of massive tourist resorts,

Table 8.4 Protected areas and protected species in Sardinia (From RAS 2003a)

Designation	Number	Area (ha)
Sites of Community importance directive 92/43	114	462,000
Natural Parks (National and Regional)	4	70,000
Marine Reserves	4	
Species of fauna protected under the directive 92/43	147	
Plant species protected under the directive 92/43	122	
Habitats protected under the directive 92/43	56 (14 of priority)	
Fauna sanctuaries established with regional decrees	85	120,000
Zones for fauna breeding/repopulation	93	69,000

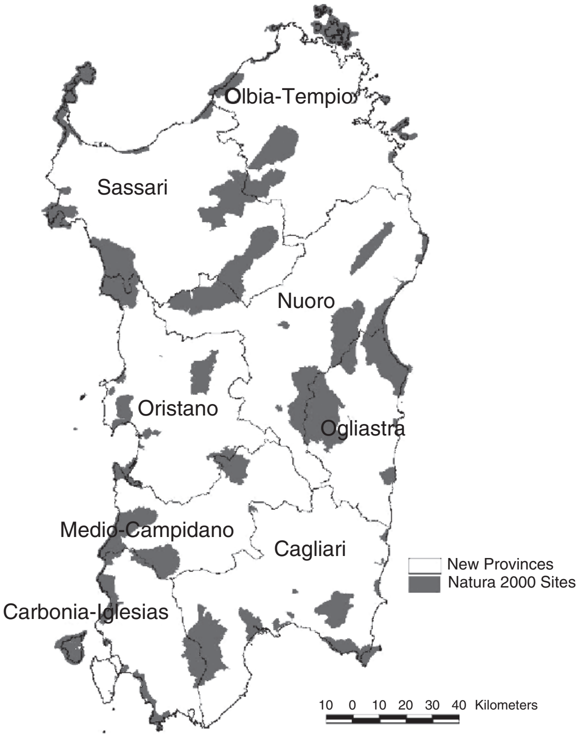

Fig. 8.12 The distribution of Natura 2000 sites in Sardinia

exploiting thus not only the natural and landscape resources, but also the local traditions. The few and delayed efforts towards landscape conservation of the end of the millennium could therefore vanish, and not only the regional, but also the national landscapes are again seriously under threat.

The current challenge is truly to reverse land abandonment, landscape deterioration and resources exploitation from foreign hands, with alternatives that could be found in cooperation with the local economic private sector and initiative. One possibility is the development of innovative environmental planning and restoration for critical areas, like the industrial archaeology of the abandoned mining sites in the South, where local tourist and entrepreneurial development could sustain landscape and environmental conservation.

8.6.2 Landscape Planning

The autonomy of the Sardinian region has conferred upon it primary authority not only in physical environmental planning, but also in landscape planning and in the sector of cultural heritage. When the Galasso Act (L. 431/85), the national law on

Landscape Planning, required that the Italian regions would draft their regional landscape plan (Pungetti 2003), the task of the Region Sardinia was facilitated by such autonomy of administrative functions. Accordingly, it was later chosen to draw up the PTP (Landscape Territorial Plan) starting directly through the Regional Town Planning Law of 1989. The coast was the area most involved in this process, because it was at that time under the restriction of temporary landscape protection against interventions in a strip of 2 km from the sea.

In the early 1990s, in order to implement the Galasso Act, the Autonomous Region of Sardinia worked on 25 areas, compacted later into 14 larger areas of landscape value. For each of these, a PTP was produced and approved in 1993. Although this was an attempt of coordination, the planning result was rather fragmented and heterogeneous since diverse methods and rules were applied by the 14 professionals employed in the process.

The 14 areas of particular landscape value, covering the greater part of the environmental heritage of the island, related to the 56.43% of the regional area, containing 53.02% of the island population (Zoppi 1992). However, since the early 1990s, it was possible to recognize how all the attempts at landscape protection expressed both by national and regional legislation had been in vain. It is in fact because of those 'exceptions' allowed in the clause of the L.R. 45/89 mentioned previously, that it was possible to grant those 'permissions' from the Region and the Municipalities, which allowed the building expansion of the tourist structures on the Sardinian coasts that otherwise would have not occurred.

This 'sack of the coast' induced a huge local protest, resulting in the institution of a Committee which gathered more than 22,000 signatures against this havoc (Stancampiano and Deliperi 1993). The Region replied with the institution of laws and decrees, which suspended building permissions along the coasts until the approval of the PTP. Beyond this attempt, however, numerous coastal developments permitted before by the regular concessions were carried out regardless.

The Region finally completed the plan and is currently starting its implementation on the whole island. The plan is part of the restructuring of the regional geographical data, called SITR (Regional Territorial Information System), within the wider European context of the proposed Directive INSPIRE (Infrastructure for Spatial Information in Europe).

8.7 Conclusions

In Sardinia landscape is deeply connected to its society, which anyhow developed differently from the rest of the Mediterranean. Sardinia is pre-eminently an island: it is one of the few Mediterranean regions which have conserved their own character. Unlike other big islands such as Sicily or Crete, where the sea was a vehicle of cultural influence and change, for Sardinia the sea proved an obstacle to cultural interchange, and at the same time a passage for foreign enemies who dominated and exploited the island (Le Lannou 1941). The need of survival resulted in a concentration of population inland, rather than on the coast, leading to the development of a distinct pastoral culture.

However, conquerors were not the only driving forces in the Sardinian society. In the post-war period, for example, society underwent a rapid shift from rural to urban (Brigaglia 1984). The social changes had strong impact on the structure of productive sectors and territorial organisation and, above all, in culture. This shift had also strong impact on the natural environment, transformed by agricultural land use and urban expansion, and consequently in the landscape. Since that period Sardinian landscapes have indeed undergone rapid modification. Agricultural improvement has produced the widespread establishment of greenhouses, while industrial and residential spread has affected agricultural ecosystems, and tourist expansion has often destroyed coastal maquis ecosystems.

An evident cultural dichotomy has indeed characterized the Sardinian society for centuries, due to the antagonism between husbandry and crop production. Shepherds, forced to find pasture through the practice of transhumance, developed a nomadic warrior class with an isolated mentality confined to the mountainous inland. Farmers, by contrast, were sedentary, pacific and practised an archaic type of agriculture close to their villages.

All the aforementioned confirm the correlation between place, society and land use. It is this correlation that has persisted over the years as the main cause of the landscape changes in the island. Here landscape planning and management however, have taken a tortuous direction. Despite the declarations of the Region to promote landscape conservation, its implementation has been weak and the Region is still far from achieving ecologically sound landscape planning and management. In an island where the link between man and land has such strong implication for the shape of its landscape, it is imperative to investigate and understand this relationship before embracing any future strategy for landscape conservation. After this, a holistic landscape strategy based on transdisciplinary approach and multifunctional use should be embraced to unify culture and nature, as advanced in Chapter 14.

References

Arrigoni, P.V. (1968) Fitoclimatologia della Sardegna. Webbia 23(1): 1–100.

Aru, A., Baldaccini, P. and Vacca, A. (1991) Nota illustrativa alla carta dei suoli della Sardegna. Regione Autonoma della Sardegna: Cagliari.

Barneschi, L. (1988) Carta Forestale della Sardegna. Stazione Sperimentale del Sughero, Settore Forestale: Tempio Pausania.

Barreca, F. (1974) La Sardegna fenicia e punica. Chiarella: Sassari.

Bocchieri, E. (1995) La connaissance et l'etat de conservation de la flore en Sardaigne. Ecologia Mediterranea 21: 71–81.

Boni, C. (1994) Flora Sarda: Alberi ed Arbusti. Edisar: Cagliari.

Boscolo, A. (1978) La Sardegna bizantina e alto-giudicale. Chiarella: Sassari.

Brigaglia, M. (1984) La Sardegna oggi. In Guida d'Italia: Sardegna. Touring Club Italiano: Milano, pp. 84–102.
Camarda, I. and Cossu, A. (eds.) (1988) Biotopi di Sardegna: Guida a dodici aree di rilevante interesse botanico. Carlo Delfino Editore: Sassari.
Cardona, M.A. and Contadriopoulos, J. (1979) Endemism and evolution in the islands of the Western Mediterranean. In D. Bramwell (ed.) Plants and Islands. Academic Press: London, pp. 133–169.
Casalis, G. (1833) Dizionario geografico storico-statistico-commerciale degli Stati di S.M. il Re di Sardegna. 1. Maspero e Marzorati: Torino.
Chessa, P. and Delitalia, A. (1997) Il Clima della Sardegna. SAR: Sardegna.
Chiappini, M. (1985) Flora e paesaggi vegetali della Sardegna. Edizioni Della Torre: Cagliari.
Commission of the European Communities (1997) Rural developments: CAP 2000 working document. European Commission DG VI: Brussels.
Council of Europe (1992) Council directive 92/43 EEC of 21 May 1992 on the conservation of natural habitats and wild fauna and flora. Official Journal of the European Communities No. L206/7.
Council of Europe, UNEP and ECNC (1996) The Pan-European Biological and Landscape Diversity Strategy: A Vision for Europe's Natural Heritage. Council of Europe, UNEP and ECNC: Amsterdam.
Da Passano, M. (1982) L'agricoltura sarda nella legislazione sabauda. In F. Manconi and G. Angioni (eds.) Le opere e i giorni: Contadini e pastori nella Sardegna tradizionale. Silvana Editoriale: Milano, pp. 76–79.
D'Angelo, M., Enne, G., Madrau, S. and Zucca, C. (2001) Land cover changes at landscape scale in Sardinia (Italy): The role of agricultural policies on land degradation. In A.J. Conacher (ed.) Land Degradation. Kluwer: Dordrecht, pp. 127–140.
De Montmollin, B. and Strahm, W. (eds.) (2005) The Top 50 Mediterranean Island Plants. IUCN/SSC Mediterranean Islands Plant Specialist Group. IUCN: Gland and Cambridge.
Delanoë, O., De Montmollin, B. and Olivier, L. (1996) Conservation of the Mediterranean Island Plants: 1. Strategy for Action. IUCN: Gland and Cambridge.
Goncalves, E. (2000) The Cork Report: A Study on the Economics of Cork. RSPB, 54 pp.
Grove, A.T. and Rackham, O. (2001) The Nature of the Mediterranean Europe. Yale University Press: New Haven, CT.
ISTAT (2001) Popolazione per sesso, età e stato civile nelle province e nei grandi comuni: anno 2001.Stime regionali al 1.1.2001. Rome.
King, R. (1975) Sardinia. David & Charles, Newton Abbot, UK.
Le Lannou, M. (1941) Patres et paysans de la Sardaigne. Arrault: Tours.
Lecis, R. and Norris, K. (2004) Habitat correlates of distribution and local population decline of the endemic Sardinian newt *Euproctus playcephalus*. Biological Conservation 115: 303–317.
Leontidou, L., Gentileschi, M.L., Aru, A. and Pungetti, G. (1997) Urban expansion and littoralisation. In P. Mairota, J.B. Thornes and N. Geeson (eds.) Atlas of Mediterranean Environments in Europe. Wiley: Chichester, UK, pp. 92–97.
Makhzoumi, J. and Pungetti, G. (1999) Ecological Landscape Design and Planning: The Mediterranean Context. Spon: London.
Marini, A., Careddu, M.B, Melis, M.T. and Pitzalis, A. (2001) Interpretation of ETM+data for natural and semi-natural areas of Sardinia – Italy. In P. Corona, S. Folving and M. Marchetti (eds.) Collecting and Analyzing Information for Sustainable Forest Management and Biodversity Monitoring with Special Reference to Mediterranean Ecosystems. Proceeding of IUFRO Conference, 4–6 December, Palermo. JRC- European Commission: Ispra, pp. 109–113.
Mayer, A. (1995) Comparative Study of the Coastal Vegetation of Sardinia (Italy) and Crete (Greece) with Respect to the Effects of Human Influence. IHW Verlag: Eching Bei Muenchen.
Meeus, J., van der Ploeg, J.D. and Wijermans, M. (1988) Changing Agricultural Landscapes in Europe: Continuity, Deterioration or Rupture? IFLA: Rotterdam.
Meloni, P. (1975) La Sardegna Romana. Chiarella: Sassari.

Mori, A. (1972) Memoria illustrativa della carta della utilizzazione del suolo della Sardegna. Consiglio Nazionale Delle Ricerche: Roma.
Naveh, Z. and Lieberman, A. (1994) Landscape Ecology: Theory and Application. Springer: New York.
Pampiro, F., Pintus, A. and Ruiu, P.A. (1991) Rapporto bosco-pascolo in alcune tipologie forestali della Sardegna: effetti. Collana Biologica 2.
Pungetti, G. (1995) Anthropological approach to agricultural landscape history in Sardinia. Landscape and Urban Planning 31: 47–56.
Pungetti, G. (1996a) Landscape in Sardinia: History Feature Policies. CUEC: Cagliari.
Pungetti, G. (1996b) Biodiversity and sustainable land use in the Mediterranean. In Ministry of Environment International Symposium on Mediterranean Biodiversity. ENEA: Rome, pp. 107–111.
Pungetti, G. (2001) Rio S. Lucia Lowland, Sardinia. In B. Green and W. Vos (eds.) Threatened Landscapes: Conserving Cultural Environments. Spon: London, p. 87.
Pungetti, G. (2003) Ecological landscape design, planning and connectivity in the Mediterranean and in Italy. In M.R.G. Mora (ed.) Environmental Connectivity: Protected Areas in the Mediterranean Basin. Junta de Andalucia, RENPA and IUCN: Sevilla, pp. 109–120.
Ruju, S. (2002) Il Peso del Sughero: Storia e memorie dell' industria sugheriera in Sardegna (1830–2000). Libreria Dessì Editrice: Sassari.
Ruiu, P.A., Pampiro, F. and Pintus, A. (1995) Analisi della rinovazione in diverse tipologie di sughereta del Nord-Sardegna. Collana Biologica 4.
Scaraffia, L. (1984) La Sardegna Sabauda. In J. Day, B. Anatra and L. Scaraffia La Sardegna medioevale e moderna. UTET: Torino, pp. 667–824.
Seghetti, G. (1928) La mano d'opera agricola e la colonizzazione in Sardegna. Tipografia del Senato: Roma.
Stancampiano, P. and Deliperi, S. (1993) Coste, Piani Paesistici e Turismo. In V. Tsetsi and I. Cirronis (eds.) Ambiente e sviluppo sostenibile Il caso Sardegna. CUEC Editrice: Cagliari, pp. 109–119.
Thompson, J.D. (2005) Plant Evolution in the Mediterranean. Oxford University Press: Oxford.
Todde, S. (2002) Monitoraggio delle formazioni di vegetazione a Juniperus oxycedrus ssp. macrocarpa sulle dune di Scivu, Piscinas e Gemma Armidas (Sardegna sud-occidentale). In H. Schenk and A. Ulzega (eds.) Dune di Piscinas, Monte Arcuentu. Amministrazione Provinciale di Cagliari: Cagliari, pp. 27–39.
Vacca, A. (2000) Effect of land use on forest floor and soil of a *Quercus suber* L. forest in Gallura (Sardinia, Italy). Land Degradation and Development 11: 167–180.
Vogiatzakis, I.N., Griffiths, G.H. and Bacchetta, G. (2005) Human impacts on *Quercus suber* woodland habitats in Sardinia: past and present. Botanika Chronika 18: 277–284.
Zoppi, C. (1992) Piano Sardegna. Verde Ambiente 2: 27–31.

Chapter 9
Cyprus

P. Delipetrou[1], J. Makhzoumi[2], P. Dimopoulos[3], and K. Georghiou[1]

Coastal landscape between Kakoskali and Loutra, in the Akamas peninsula (photo by P. Delipetrou)

9.1 Introduction

Cyprus, the third largest Mediterranean Island in size (Fig. 9.1), is situated in the north-eastern part of the Mediterranean Sea, 33° east of Greenwich and 35° north of the Equator and has an area of 9,251 Km^2, of which 1,733 are forested. Distance

[1] Department of Botany, Faculty of Biology, University of Athens, Greece

[2] Faculty of Agricultural and Food Sciences, American University of Beirut, Lebanon

[3] Department of Environmental and Natural Resources Management, University of Ioannina, Greece

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Fig. 9.1 Map of Cyprus with the main urban centres

from the mainland ranges from 75 km from Turkey in the north to 150 km from Syria in the east and 380 km from Egypt in the south, while in the west the closest shores are the Greek islands of Karpathos and Rhodes at 380 km. The population of Cyprus is 755,000 of whom 643,000 are Greek Cypriots, 88,000 are Turkish Cypriots and 24,000 are foreigners residing in Cyprus. Since the Turkish invasion and occupation of over a third of the island, the demographic balance has changed dramatically as a result of Turkey's policy. There are around 115,000 illegal Turkish settlers in the occupied area, while a considerable number of Turkish Cypriots have emigrated.

Lefkosia (Nicosia) has been the capital of Cyprus since the 11th century BC. It is situated roughly in the centre of the island and is the seat of government as well as the main business centre. Lemesos (Limassol), extending along the south coast, is the second largest town and the main commercial port. Larnaka, a commercial centre and the seat of the European Consulates in the 18th century, is now the island's second commercial port and also an important tourist resort. Pafos in the south-west is a fast developing tourist resort, and has an attractive fishing harbour. Ammochostos (Famagusta), the centre of the pre-1974 tourist industry is now a ghost town. Keryneia (Kyrenia), the main coastal urban centre in the north, is now inhabited almost exclusively by Turkish Cypriots and Turkish settlers.

The prehistory of Cyprus starts in the Late Paleolithic and Pre-Pottery Neolithic with the first traces of human habitation 9,000 years ago. In the Bronze Age the island was influenced by the Achaean Greeks and in the Iron Age there was a fusion of Cypriot, Mycenaean and Syro-Anatolian elements. In the Geometric

Table 9.1 Main periods in the prehistory and history of Cyprus

Period	Duration
Late Paleolithic Period	9000–7000 BC
Neolithic Period	7000–3800 BC
Chalcolithic Period	3900–2500 BC
Early Bronze Age	2500–1900 BC
Middle Bronze Age	1900–1650 BC
Late Bronze Age	1650–1050 BC
Geometric Period	1050–750 BC
Archaic Period	750–475 BC
Classical Period	475–325 BC
Hellenistic Period	325–50 BC
Roman Period	50 BC–395 AD
Byzantine Period	395–1185
Frankish Rule	1191–1489
Venetian Rule	1489–1571
Ottoman Rule	1571–1878
British Colonial Rule	1878–1960
Cyprus, an Independent Republic	1960
Turkish Invasion	1974

Period Cyprus was a Greek island with ten city kingdoms. The island experienced Assyrian and Egyptian domination (9th–8th century BC), Phoenician settlement (Kition), Persian domination (6th century BC) until in the 4th century BC Evagoras unified Cyprus. Cyprus eventually came under the Hellenistic state of the Ptolemy of Egypt until the Roman period. For almost eight centuries, Cyprus was under the administration of the Byzantine Empire of the East until 1192 when it was sold to the Knights Templar and Lusignan. After a Frankish period (until 1489) and a Venetian period (until 1571) Cyprus came under the Ottoman Rule, until 1878 when it came under the British Rule (Table 9.1). The Republic of Cyprus was established in 1960.

The current landscape of Cyprus is the product of the influence of a long colourful history on the varied abiotic and biotic characteristics of the island. The physical environment is characterized by a rugged morphology and varied geology. The climate of Cyprus is in general at the drier end of the Mediterranean-type climates. The biotic elements are characterized by considerable diversity and endemism taking into account the size of the island. The rural landscape is dominant and usually intermixed with natural elements. The most remarkable recent landscape changes in Cyprus have been brought about by overexploitation of the coastal areas, urbanization, massive population movement, water exploitation, the shift from agricultural to tourism economy and also by an effort towards reforestation and by recent sustainable development policies. Besides having become a national strategy target, landscape conservation is also favoured by European Union (EU) legislation.

9.2 Physical Environment

9.2.1 Climate

Cyprus has a Mediterranean climate with typical seasonal variation: hot dry summers from mid-May to mid-September and rainy winters from November to mid-March are separated by short autumn and spring seasons subject to unstable weather systems (Meteorological Service 1986). The annual average precipitation is about 500 mm but it was as low as 182 mm in 1972/1973 and as high as 759 mm in 1968/1969 (Rosse 2001), while minimum precipitation averages from 300 mm at Mesaoria to 1,100 mm at the peak of Troodos. Local meteorological phenomena are influenced by the two mountain ranges, Troodos and Pentadaktylos, and also by the proximity to the sea (Meteorological Service 1986). The dry period ranges from 7 months to 7.5 months in areas with altitudinal range 0 m to 350 m a.s.l, from 6 months to 7 months at altitudes ranging from 400 m to 850 m a.s.l, and from 4 months to 5 months at mountainous (850 m) and high mountainous (1,700 m) areas.

The bioclimate of Cyprus has been classified according to the climagram of Emberger (Emberger 1930; Daget 1977) and according to the classification system by Rivas-Martínez et al. (2004). The application of Emberger's pluviothermic coefficient (Q2 = 2000 P / M2 – m2, where P = annual precipitation, M = mean of the maximum temperatures of the hottest month in the year, m = mean of the minimum temperatures of the coldest month) applied to 35 meteorological stations of the island resulted in four bioclimatic belts from arid ($15 < Q2 < 25$) to humid ($95 < Q2 < 145$) with thermic variants ranging from hot ($m > 7$) to harsh ($-3 < m < 0$) winters. According to the Rivas-Martínez bioclimatic classification, Cyprus has a Mediterranean Mesophytic to Xerophytic-Oceanean bioclimate with zones ranging from Thermo-Mediterranean – semi-arid (lowlands) to Supra-Mediterranean-humid (Troodos) (Barber and Valles 1995; Andreou and Panagiotou 2004). Eight bioclimatic zones (Table 9.2) have been mapped according to a combination of the above systems (Pantelas 1996).

Table 9.2 Bioclimate zones of Cyprus (After Pantelas 1996)

Bioclimatic belt	P (mm)	M (°C)	Altitude (m)
Semiarid Hot	<400	>6	<100
Semiarid Mild	<400	3–6	<100
Hot Arid	400–600	>6	0–300
Mild Arid	400–600	3–6	300–400
Semi Wet Mild	600–900	3–6	400–900
Semi Wet Cool	600–900	0–3	900–1150
Cool Wet	>900	0–3	1,150–1,500
Cold Wet	>900	<0	>1,500

9.2.2 Geology

In Cyprus geological processes have played an important role in the development of the natural environment. The island came into being as a result of a series of unique and complicated geological events. Some 90 million years ago, part of the bottom of a deep ocean, called ‘Tethys’, was subject to tectonic movements resulting in the collision of the African and Eurasian plates which gave birth to Cyprus.

About 20 million years ago, two small islands rose above the sea: the forerunners of the Troodos and the Pentadaktylos ranges (Fig. 9.2), which reached their present height about 1–2 million years ago. The ocean crust now exposed at the tip of the Troodos mountain range is an ophiolite which formed 8,000 m below sea level. This was later thrust tectonically to almost 2,000 m a.s.l. The range mostly consists of basic and ultra-basic plutonic rocks (gabbros, diabase, peridotites, dunites and serpentinized harzburgites). Pentadaktylos (Kyreneia range) rises up to c.1,000 m and is made of a succession of mostly allochthonous sedimentary formations. The third major geological terrain is the Mammonia complex in the hilly south-west part of the island (Fig. 9.3). The Mesaoria plain which joins the two mountain ranges is traversed by the rivers Pediaios and Serrachis and mainly formed by alluvial–colluvial soils and also by fanglomerates, biocalcarenites, sandstones and sandy marls with gypsum outposts. The geomorphological characters have produced a varied topography which is now characterized by a variety of microclimates and hence habitats. The coastline of Cyprus ranges from steep inaccessible cliffs and ragged rocky shorelines with sea caves to gentle sloping sandy beaches. Coastal typology includes hard rocks (e.g. Akamas, Cavo Greco)

Fig. 9.2 The principal mountains and river network of Cyprus

Fig. 9.3 Mamonia formation south-west Cyprus (Photo courtesy of Ch. S. Christodoulou) (*See Colour Plates*)

and sand gravel (e.g. Ammochostos, Lemesos) moderately exposed bays of intermediate (30–50 m), mostly, or shallow (<30 m), depth (Argyrou 2000; Argyrou et al. 1999; WL Delft 2004). Most rivers originate in the Troodos range and have steep slopes, except for the rivers in the lowland areas along the southern coast (Water Development Department 2004). There are no rivers with perennial flow along their entire length; only parts of some rivers upstream in the Troodos areas have a perennial flow, such as Xeros, Diarizos and Kargotis (WL Delft 2004). Springs are also mostly located on Troodos and although they are not large enough to contribute substantially to river flow, they are used for supplying drinking water to many villages of the Lemesos and Lefkosia districts (WDD-FAO 2002).

9.3 Biotic Elements

9.3.1 Flora and Vegetation

Cyprus is an island with diverse landscapes due to varied climate and geology, and its proximity to Asia, Africa and Europe. In addition its size (9,251 km^2) is sufficient to support high species and habitat diversity but isolated enough (since the Miocene salinity crisis) for significant endemic biota to form (Böhme and Weidl 1994; Blosat 1998). At the same time, human impact on the island has been long-lasting. Human presence on the island dates back to 10,000–12,000 years ago when sailor-hunter colonizers first arrived (Simmons 1999). Animal husbandry and farming and consequent plant and animal species introductions started as early as 9,000 years ago (Keswani 1994; Guilaine and Briois 2001; Croft 2002). The landscape of modern Cyprus is a mosaic of natural or semi-natural biotopes at various stages of succession, alternating with large areas of cultivation and urban centres.

Evidence from pollen analysis suggest that early Holocene Cyprus was covered by dense forests of typical Mediterranean trees and shrubs, such as *Ceratonia siliqua, Cupressus, Juniperus, Quercus coccifera, Quercus infectoria subsp. veneris* (Box 9.1), *Laurus nobilis, Olea europaea*, and also riparian *Platanus orientalis* (Holmboe 1914; Bottema 1966; Karali 1996; Palamarev 1987; Hansen 2001). In ancient times Cyprus was a ‘Green Island’, a ship-building centre and timber exporting country (Thirgood 1987). Pine and cedar are reported as important forest species by Theophrastus and according to Eratosthenes (3rd century BC) the island was ‘thickly overgrown with forests’ (Hadjikyriakou 2000).There are indications that even the arid plain of Mesaoria was once covered by forest (Jones et al. 1958). Felling started in the Bronze Age along with copper mining. The island went through great fluctuations in population and prosperity and so did the use or abuse of forests. The mines which were in operation from the Phoenician to the Roman period (Table 9.1) provided masts for ships and metal for trade, and led to periods of intensive felling. However, land clearing for cultivation, fire and unrestricted goat grazing have been the main causes of deforestation (Madon 1881; Thirgood 1981) and the consequent erosion (Jenness 1962). This was exacerbated during the Ottoman Occupation (1571–1878), especially during its last 100 years (Thirgood 1987). At the time of the British administration (1878), when the first official forest survey took place, the forests were devastated, even at places not fit for productive cultivation (Thirgood 1987). Moreover, uncontrolled land management led to the degradation of the deep, humus rich soils (Fig. 9.4) that had been widespread (Jones et al. 1958).

Today, the potential natural vegetation of Cyprus is a matter of speculation, as little of it remains. However, after 140 years of rational forest management, forests cover c.20% of the island (Forestry Department 2004) extending on the main part of the Troodos massif with outposts on the eastern Akamas mountains and on the northern Pentadaktylos range (Fig. 9.5). The slopes of the forested mountains are flanked by various types of matorral which extend south of Troodos to the coast, creating the largest continuum of natural biotopes on the island; south-east of Akamas; and east of Pentadaktylos on a green line to the edge of Karpasia. The expanses of cultivated land, c.45% of Cyprus, lie among the mountains, and occasionally within the forested areas and extend to the coastal zone. The vast cultivated areas of the fertile soils of Mesaoria (Fig. 9.6) are only broken by small fragments of low matorral or small patches of bushes or tree stands.

The thermophilous pine forests with *Pinus brutia* are the most extensive and widespread comprising c.66% of forest land; they occur on virtually all the mountainous areas from sea level up to 1,400 m and from dry to sub-humid climate. The Troodos range is well covered with thick pine woodlands, which attain their best development in Pafos forest (Fig. 9.7), where the largest unfragmented and

Fig. 9.4 Pastures and eroded slopes in Pafos (Photo courtesy of Ch. S. Christodoulou) (*See Colour Plates*)

Fig. 9.5 Vegetation map of Cyprus

best conserved *Pinus brutia* forests are found. Pines are locally mixed with cypress (*Cupressus sempervirens*) on Pentadaktylos range. There, on the limestone slopes and rocky crests, cypress is at its optimum and forms pure stands almost all along the length of the range.

Fig. 9.6 Mesaoria: Fields, olive groves and patches of natural vegetation (Photo courtesy of P. Delipetrou) (*See Colour Plates*)

Fig. 9.7 Pafos forest: natural regeneration on the right and reforestation on the left after 33 years of the fire event (Photo courtesy of Ch. S. Christodoulou)

The Troodos range, with the most humid and cool areas in Cyprus, is also home to montane conifers, black pine, cedar and junipers, and to the endemic evergreen golden oak, *Quercus alnifolia*. The black pine, *Pinus nigra* subsp. *pallasiana*, forms a single forest with a total area of 3,488 ha starting at 1,200–1,500 m and extending up to Chionistra peak (there are only another two small outposts on the peak of Madari). Despite efforts for its protection, the black pine is under considerable threat. Natural regeneration seems to be minimal while the fire prone and fire adapted *Pinus brutia* expands its habitat at the expense of the non-serotinous, fire-evading black pine. Moreover, in the event of climate warming the habitat of the black pine (which is in Cyprus at the southernmost end of its distribution) will shrink to the higher altitudes (C.A. Thanos 2004, pers. comm.).

Cedrus brevifolia, the endemic Cyprus cedar, one of the four species of cedar in the world, growing in a warmer climate and also rarer than its three congeners, is confined to the subhumid to humid zone of Pafos Forest. The main, dense cedar forest occupies the peak and the slopes of Tripylos, but scattered small patches occur on the surrounding mountain slopes at altitudes ranging from 800 to 1,400 m. The montane junipers, *Juniperus foetidissima, J. oxycedrus* and *J. excelsa* are chiefly found in the understorey of pine forest above 1,000 m, occasionally forming small stands at the topmost slopes of Chionistra and Madari peaks. The sclerophyllous golden oak is chiefly found in the understorey of the conifers but it also forms pure stands, mainly at high altitudes in Pafos forest and Troodos. The species has the ability to establish itself on screes where no other trees manage to grow and where it functions as a stabilizer (Fig. 9.8). The semi-deciduous oak, *Quercus infectoria* subsp. *veneris*, although widespread and supposedly the potential vegetation of a large part of west Cyprus at altitudes between 600 and 1,000 m (Jones et al. 1958; Barbéro and Quézel 1979), is chiefly found in small stands or isolated trees among fields (see Section 9.7).

The landscape of the lowlands is dominated by open shrub formations. Evergreen, sclerophyllous Mediterranean shrubs (c.30% of the island) at various stages of development (or degradation), depending mainly on human impact, are widespread in uncultivated areas. The thick and tall olive, carob and lentisc maquis as well as the *Quercus coccifera* subsp. *calliprinos* formations, which include deciduous shrubs at higher altitudes, are the rarest communities and have best survived at Karpasia, Akamas and on the southern slopes of Troodos. At the other end, the low, hemispherical phrygana formations occupy drier and grazed areas and are the pioneer species on abandoned fields. Between these two communities, there is a range of open or closed formations covering large areas and hosting a large variety of shrubs and herbs, including endemic and rare species. The coastal shrub is characterized by the Phoenician juniper, *Juniperus phoenicea*, and ranges from the high woodland of Apostolos Andreas at Karpasia, to the arborescent matorral of Akamas and to the wind shaped, mat-like shrub of Cavo Greco. Notably, both Cavo Greco and Karpasia were once covered by tall and thick junipers (Thirgood 1987). On the other hand, the inner semi-arid zone is characterized by a type of xerophilous shrub with *Crataegus azarolus* and by the open *Zizyphus lotus* matorral which, due to the intense cultivation of its natural area, is today represented by isolated shrubs and rarely by small stands.

The sandy coastal zone, due either to geomorphology or to human activities, is generally narrow with ammophilous communities on low embryonic and shifting dunes. Extended dune systems, including stabilized dunes with shrubs and dune slacks, develop at few places (Apostolos Andreas at Karpasia, Akamas), notably in

Fig. 9.8 Troodos Mountain: eroded slopes with screes on diabase vegetated by *Quercus alnifolia* (Photo courtesy of Ch. S. Christodoulou)

connection with wetlands, i.e. Ammochostos, Agia Eirini and the salt lakes of Akrotiri and Larnaka. Although land reclamation has reduced the area of wetland substantially, there are still areas with halophytic vegetation of glassworts, sea-blites, purslane and tamarisks (Fig. 9.9). Flowing water bodies are many but mainly intermittent. A discontinuous and mostly narrow line of riparian shrub and forest develops along the numerous streams that dissect the island, often offering an oasis of natural habitats in the midst of cultivated land (Fig. 9.10). Standing freshwater bodies are only artificial storage basins and dams, yet, hydrophilous vegetation has established at most of them.

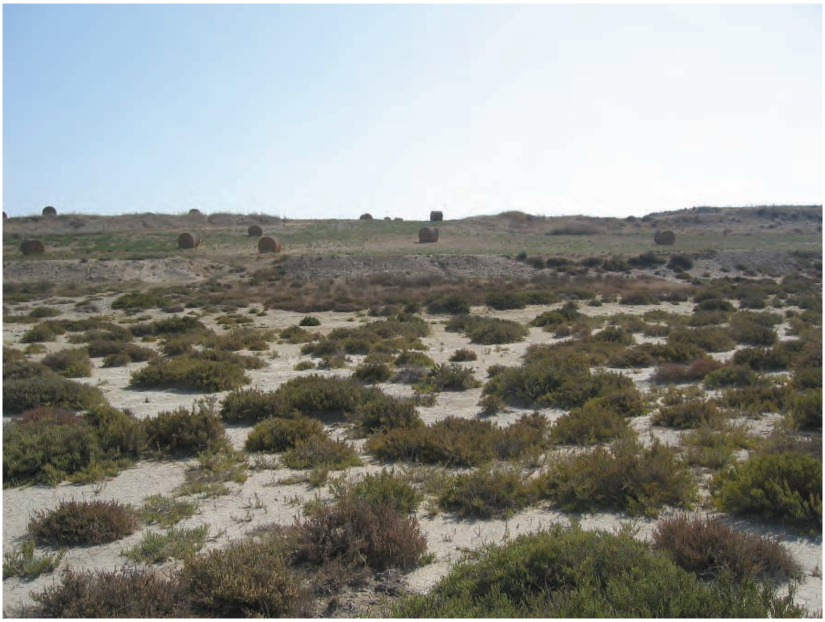

Fig. 9.9 Land reclamation in the wetlands of Larnaka (Photo courtesy of M. Andreou)

Plantations of mainly exotic trees, such as *Acacia* spp., *Eucalyptus* spp., *Pinus halepensis*, established mainly up to the 1930s (Thirgood 1987), but also in later years either for fuel or for stabilization and even for afforestation, cover c.1.3% of the island (Forestry Department 2004). Afforestation saved many sites from erosion, grazing and building and also made a fundamental change to the attitude of the people to trees for shade and as a feature of the landscape (Thirgood 1987). Nevertheless, planting altered the natural landscape with alien species which in some cases proved to be invasive. *Acacia saligna* (Fig. 9.11) has managed to intrude in salt marshes and in riparian wetlands (Christodoulou 2003a) and is capable of expanding on sand dunes (Hadjichambis 2005). Acacias have been planted to such an extent that it would be no exaggeration to say that an unwary visitor would believe them to be common components of the native flora.

Botanical research on the island started in 1787 and was epitomized in the 1980s in the *Flora of Cyprus* (Meikle 1977, 1985). Since then, there have been a considerable number of additions and the flora can be considered to be very well known. In total, the native flora includes 1,610 species or 1,738 taxa to variety level (Hadjikyriakou 1997; Cyprus Flora 2005). This species diversity is lower than that of similar sized continental areas but the more appropriate index *log*species/*log*area is 0.81, comparable to those of other large Mediterranean islands, such as Crete (0.83) and larger than those of Italy (0.68) and Greece (0.73) (Delipetrou and Georghiou 2000; Pignatti 1995; WWF & IUCN 1988; Davis et al. 1994).

Habitat diversity, the varied topography and geographical position (Cyprus incorporates floristic elements of the neighbouring Africa and Asia) are the keys

Fig. 9.10 Riparian forest with *Alnus orientalis* in the dry hilly areas of south-west Cyprus (Photo courtesy of Ch. S. Christodoulou) (*See Colour Plates*)

to species diversity in Cyprus. There is a large number of plants (c.500) which are rare even if widespread or they are locally common but not widespread (Cyprinia 2005). In many cases rarity is apparently the result of a restricted ecological niche. *Calamagrostis epigejos*, a species widespread in many habitats in Europe, is at the southernmost edge of its distribution in Cyprus and confined to a small area of the unique high altitude peat grassland. Also, the rare carnivorous *Pinguicula crystallina* is found in small patches solely at high altitude wet rocks along with the orchid *Epipactis veratrifolia*, which is rather rare but abundant in this habitat. The Mediterranean limestone chasmophyte *Umbilicus horizontalis*

Fig. 9.11 *Acacia saligna* invasion in the wetlands of Larnaka (Photo courtesy of M. Andreou)

occurs in very small populations at a few sites from Cavo Greco to Pentadaktylos. On the other hand, the serpentine endemics *Alyssum troodi* and *Alyssum cypricum* grow abundantly on Troodos, but only there. Notwithstanding the large number of rare plants, there are as yet no confirmed extinctions of native species in the modern era (IUCN 1993; Cyprinia 2005). There are several species that have not been seen for 150–100 years, but this may be due to misidentifications while searches for others have not been made (Cyprinia 2005). Yet, there are one or two cases of likely extinctions, such as *Cionura erecta* which is not found today on the highly developed coast between Lemesos-Amathus, where it had reportedly been common on sand dunes in 1905 (Meikle 1985; C.S. Christodoulou 2005, pers. comm.).

There are 108 endemic plant species (143 taxa) comprising 6.7% of the flora (Cyprus Flora 2005) and corresponding to 12 species per 1,000 km^2. Quantitatively (Samways 1995) endemism is 2.4 times more than expected for the size of Cyprus. Troodos, with a total of 720 species, of which 72 are endemic to Cyprus and 12 are local endemics (Christodoulou 2003b), is the hot spot of endemism but endemics occur throughout the island. Some are widespread and common, such as the thistle *Onopordum cypricum* which grows at a variety of habitats. Others characterise forests, such as the trees *Cedrus brevifolia* and *Quercus alnifolia*. Yet, some others are very rare, such as *Arabis kennedyae* and *Crypsis hadjikyriakou* which only occur at less than five locations each and have a low total population size (Raus and Scholz 2004; Cyprinia 2005). The relict element of the island flora is represented by a

Box 9.1 *Quercus infectoria subsp. veneris*

Quercus infectoria subsp. *veneris* is a semi-deciduous oak occurring in the eastern Mediterranean and Middle East through to Iran (Meikle 1977). As one of a group of Mediterranean oaks occupying deep soils of residual forest communities, it was more extensive in the forests of the last cold stage (Schiller et al. 2004) which are now dominated by *Pinus brutia* or matorral (Quézel and Barbéro 1985). In Cyprus *Q. infectoria* subsp. *veneris* occurs mainly on the northern and southern slopes of the Troodos massif (Fig. 9.12). Isolated individuals are widespread; some are giant and protected as Nature Monuments, e.g. the Lagoudera oak c.800-years old (Forestry Department 2005). Scattered forest thickets at 600–1000 m a.s.l. are common though individuals occur up to 1,450 m in *Q. alnifolia* and *Pinus nigra* forest. The largest thickets have a distinct floristic structure which corresponds to a recognizable syntaxon (*Quercion calliprini: Quercetalia ilicis: Anagyro foetidae-Quercetum infectoriae,* Barbéro and Quézel 1979). Such communities may be remnants of the climatic climax forest of the limestones of the Troodos (Zohary 1973; Barbéro and Quézel 1979) resulting from long term agricultural expansion onto the deep soils. Felling, grazing and accidental fires have also caused degradation to maquis, phyrgana, or the undergrowth of *P.brutia* forest (Zohary 1973; Barbéro and Quézel 1979).

Despite the value of the oak to society, felling to reduce encroachment on agricultural land and for fuel have been widespread (Jenness 1962). In contrast Troodos villagers have protected oaks to ensure a good acorn crop for pigs (Tsintides et al. 2002). Although oak forests 'yield first rate timber and are one of the most valuable assets of the island' (Hutchins 1909), their restoration have never been promoted in Government plans. Today, however, land abandonment, reduced felling and avoidance of wood fuel means that pressure on the oak is reduced. Coupled with the designation of remaining woodlands as protected habitats (Council of Europe 1992), this has promoted restoration programmes by the forest service. Recent expansion of the species onto abandoned land (Fig. 9.13) and successful vegetative regeneration following fire indicate potential for future spread with the numerous stands traditionally left at field or stream borders providing propagules and acting as core areas from which colonization can occur. The well-documented Vouni Panagias woodland provides an insight into *Q. infectoria* subsp. *veneris* dynamics. It occurs in small stands on deep soils and as individuals along field margins or within fields; on rocky limestone slopes, mature trees occur in tall thickets dominated by *Q. coccifera*. Floristic analysis by Delipetrou (Delipetrou 2006, pers. comm.) classifies these thickets as *Q. infectoria* communities. Even though they may be degraded *Q. infectoria* woodlands (Fig. 9.14), they are included in habitat type 93A0 since they are considered to have the potential to develop naturally into proper woodland.

Fig. 9.12 *Quercus infectoria* stands at the borders of vineyards and fields at Vouni Panagias (Photo courtesy of M. Andreou) (*See Colour Plates*)

Fig. 9.13 Regeneration of *Quercus infectoria* and other trees-shrubs at abandoned fields with low intension grazing at Lapithiou (Photo courtesy of M. Andreou) (*See Colour Plates*)

Fig. 9.14 Shrub with *Quercus coccifera-Pistacia terebinthus* and young *Quercus infectoria* at rocky slopes at Vouni Panagias (Photo courtesy of M. Andreou) (*See Colour Plates*)

number of species. *Zizyphus lotus* and *Pistacia atlantica* are believed to be relicts of a former warmer period when xero-tropical elements covered part of their present Mediterranean territory (Zohary 1973). The endemic *Bosea cypria*, a bush occurring at rocky places all over the island, is believed to be an element of the Tethyan-Tertiary period (Meikle 1977).

9.3.2 Fauna

The terrestrial vertebrate fauna includes 30 species of mammals, 22 reptiles and 3 amphibians (Iezekiel 2001, unpublished data). Endemism is significant but probably not as high as would be expected by the long isolation of the island (Göçmen and Böhme 2002). There had been an earlier rich fauna, including the endemic pygmy hippo (*Phanourios minutus*), the pygmy elephant (*Palaeoloxodon cypriotes*) and *Crocidura suaveolens praecypria* which became extinct at the end of the Pleistocene (Bate 1904; Blosat 1998; Simmons 1999; Davies and Lister 2001; Iezekiel 2001). This extinction has been attributed to the epipaleolithic or early pre-pottery Neolithic hunters (Simmons 2001; Reese 2001), but this is not universally accepted (Olsen 1999; Binford 2000; Smith 2000; Dewar 2001). The endemic Cyprus mouflon, *Ovis orientalis ophion*, the smallest wild sheep on earth, which lives in the thick forests of Pafos, first appeared in Cyprus in the Neolithic period (8000 BC), probably introduced by humans as a domesticated wild sheep race (Hadjisterkotis 1996; Hadjisterkotis and Bider 1997). The mammal fauna also includes 18 bat species, which are rather thinly spread all over the island. *Rousettus aegyptiacus*, the fruit bat, almost became extinct in the 1980s due to persecution but is now recovering (Hadjisterkotis 2001). The European fox, the lesser white-toothed shrew and the hedgehog are represented by endemic subspecific taxa and there is an endemic spiny mouse species, *Acomys nesiotes*. Among the reptiles, there are seven endemic subspecific taxa and one species, *Coluber cypriensis* (Cyprus whip snake). Two rare endemic reptiles live in streams and ponds, the tortoise *Mauremys caspica rivulata* and the Cypriot Grass Snake, *Natrix natrix cypriaca*, which is now endangered, its decline probably due to the extensive use of DDT in the 1950s and 1960s. The marine herpetofauna includes both the sea turtles of the Mediterranean, *Chelonia mydas*, the most widespread, and *Caretta caretta*.

The resident bird fauna comprises 36 species (Iezekiel 2001, unpublished data), includes 2 endemic species, *Sylvia melanothorax* and *Oenanthe cypriaca*, and 5 more endemic taxa, which makes Cyprus the number one location for bird endemism in Europe and one of the 221 in the world. The endemics are generally widespread on the island though there is a unique population of *Loxia curvirostra guillemardi* on Troodos. Cyprus is also one of the eight main migratory bird routes from North to South and vice versa, and during the spring and autumn passage millions of nocturnal and diurnal migrants stop over. Close to 20,000 flamingos overwinter at the salt lakes of Alykes and Larnaka, a large number of herons and egrets gather at Chrysochou Bay and the freshwater dams support an increasing number of ducks and waders. Eleonora's falcon nests at the rocky coasts of Akrotiri, Episkopi and cape Aspro, and seagulls and swifts nest at the islets off Akamas and Apostolos Andreas cape, the only place where the Audouin's gull breeds. Raptors, including *Accipiter gentilis, Hieraaetus fasciatus* and the rare *Buteo rufinus*, prey in large numbers in Pafos forest and the river valleys south of it and also at Vouni Panagias and Akamas.

9.4 Cultural Landscapes

In Cyprus, as elsewhere in the region, landscape is the outcome of interaction between people and Mediterranean ecosystems. Over a period of more than 10,000 years, anthropogenic influences through burning, grazing, cutting, coppicing as well as terracing and cultivation, degraded the Mediterranean native forest into maquis, garigue, batha and grass communities and converted the land into agricultural and pastoral landscapes (Naveh 1975). Historically, the landscape of Cyprus, Biblical Chittim, was densely forested, making the island a prize possession to early maritime civilizations. By the late 19th century successive occupation and intensive exploitation had reduced the forest area to that of the most inaccessible peaks (Thirgood 1987), while converting previous forestland into a diverse human-maintained cultural landscape.

The landscape in Cyprus is predominantly rural and characteristically Mediterranean. A comprehensive survey in the 1950s (Table 9.3) listed eight broad land-use categories (Christodoulou 1959). A reassessment 50 years later, based on satellite data and CORINE Landcover classification (MANRE 2005b), shows a dramatic reduction in the proportion of cultivated land, mainly of permanent crops (fruit trees, olives, vineyards), in favour of woodlands and built up areas (Table 9.3).

The traditional land-use pattern in Cyprus is largely a product of the island's diverse geomorphology which permits a diversified crop production. Four features predominate (Section 9.2): *mountains*, the Troodos to the southwest and the

Table 9.3 Land-use change in Cyprus 1950–2000 (From Christodoulou 1959; MANRE 2005)

		Cover %	
Land-use Category	CORINE landcover class level 2	1950s	2000
Settlements and associated non-agricultural lands		0.17	7.07*
	1.1 Urban fabric		4.79
	1.2 Industrial, commercial and transport unit		1.74
	1.3 Mine, dump and construction site		0.54
Horticulture with orchards and town gardens		0.14	0.54*
	1.4 Artificial non-agricultural vegetated areas		0.54
Trees and other perennial crops, mainly olive and carob		31.81	3.86
	2.2 Permanent crops (incl. vineyards, fruit trees, olive groves)		3.86
Crop land		39.64	43.96*
	2.1 Arable land (irrigated and non irrigated crops)		28.51
	2.4 Heterogeneous agricultural areas (incl. natural vegetation patches)		15.45
Unimproved grazing		17.5	0.09*
	2.3 Pastures		0.09
Woodlands including dense, open woodland and scrub		10.1	40.63*
	3.1 Forest		16.84
	3.2 Shrub and/or herbaceous vegetation associations		23.79
Swamps and marshes		0.27	0.21*
	4.2 Coastal wetlands		0.21
Unproductive land		0.37	3.64*
	3.3 Open spaces with little or no vegetation (incl sand dunes, bare rocks, burned areas)		3.49
	5.1 Inland waters		0.15

*The 2000 cover values are the sums of the CORINE classes listed in the second column.

Pentadactylos range along the north coast; *foothills*, the hilly terrain and plateaus associated with the two ranges; *plains*, the inland plain of Mesaoria and smaller coastal plains; *ravines*, both short steep seasonal river courses punctuating the coastal plains and broader ones in the Mesaoria. The central plain of Mesaoria is the single large continuous cultivated expansion in Cyprus. Winter rainfall crops, mainly cereals (wheat and barley), are grown in the eastern part. The western part, fed by the rivers of Troodos and traditionally irrigated by a complex system of conduits, is additionally cultivated with potatoes, vegetables, legumes and fodder. The predominant features of the coastal plains are the irrigated citrus orchards the expansion of which during the 1960s caused salinization of the groundwater and their subsequent desiccation in many areas. The hilly terrains, especially at Lemesos and Pafos, are characterized by vineyards, a crop with a history of 5,500 years in Cyprus, now covering no less than 23,500 ha of submountainous and mountainous, stony and rocky land where other cultivations are financially not viable. The narrow Troodos valleys are wherever possible terraced and planted with fruit and nut trees.

Spatial limitations, evolutionary processes and the proximity of marine and terrestrial ecosystems in Mediterranean Islands enhance the alignment between landscape and ecosystem. The complex relationship between landscape and ecosystems in Cyprus contributed to the development of distinct landscape character zones, *ecological landscape associations* (Makhzoumi and Pungetti 1999). In the Kyrenia Region, for example, four ecological landscape associations are distinguished (ibid. 237). The first corresponds to the forest that occupies the Pentadactylos peaks and approximates more than any other to natural dominant ecosystems. A second consists of rich scrubland, namely of Mediterranean maquis, which dominant the northern aspect of the upper foothills. Perennial cropping of olive and carob trees, in association with stone terraces in the foothills and in ravines, form a third and fourth category of associations, albeit cultural ones. The various landscape associations are the building blocks of the regional landscape mosaic (Fig. 9.15). Perennial tree cropping, predominantly of olive (*Olea europaea*) and carob (*Ceratonia siliqua*) and to a lesser extent almond (*Prunus dulcis*), is the most enduring component of the cultural landscape in Cyprus. Olive and carob are native to the Mediterranean, well adapted to the seasonally dry, semiarid climate (Meikle 1977, 1985; Quézel and Barbéro 1985). Archaeological evidence indicates that olive production in Cyprus dates to the Bronze Age (2500–1050 BC) and that it is linked to the development of maritime communication (Hadjisavvas 1992). Carob seeds were an equally valuable export in Cyprus from the 15th century to the early 20th (Jenness 1962). Perennial tree cropping, however, is not only valued in terms of tree production, olive and carob pods, but equally for the agricultural and pastoral uses accommodated within their spatial framework. Variously known as *multi-use tree plantations* (Makhzoumi 1997), *ager-saltus-sylva*, agro-sylvo-pastoral systems (Blondel and Aronson 1999), this landscape represents an age-old land management system in the Mediterranean that combines several rural activities in a single space to optimize microclimatic and edaphic variations. Consequently multi-use plantation ensures efficient use of natural and human resources through diversification of production, since multi-use plantations are in themselves sustainable. They also

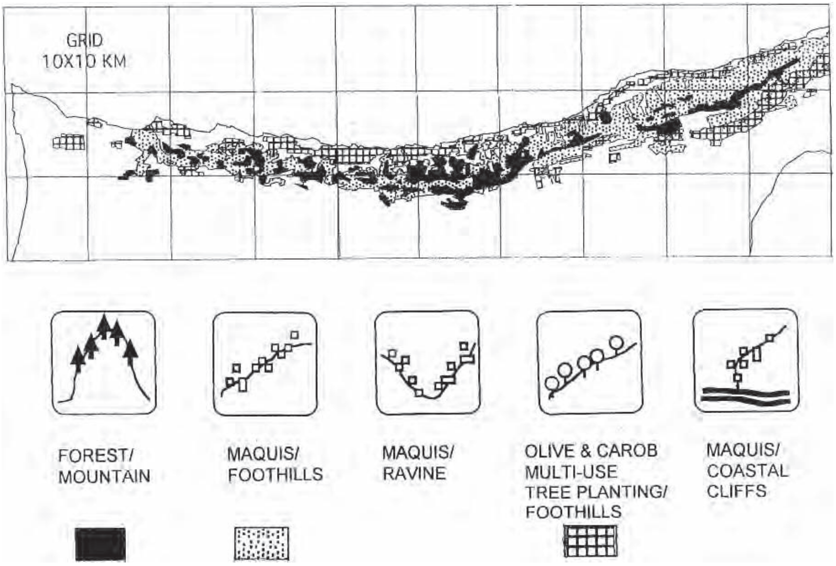

Fig. 9.15 Key landscape associations form the building blocks of the cultural landscape mosaic (Makhzoumi and Pungetti 1999; With permission from Routledge)

sustain the marginal environment they occupy, where the soil is too shallow for conventional, arable uses. It follows that multi-use landscapes of olive and carob in Cyprus should be valued for their environmental role, because they protect watersheds and terrains that are vulnerable to soil erosion. Similarly these landscapes play an important ecological role as wildlife habitat; their wide distribution ensures landscape continuity from mountain peak to coast (Makhzoumi and Gunduz 2002).

The extent and environmental and ecological significance of multi-use olive plantation in Cyprus is considerable. A survey of olive landscapes conducted in the north of the island represented by the coastal and inland foothills of the Pentadactylos and the island's northern coast, provides insight into the flexibility of these traditional landscapes (Makhzoumi 2001). Depending on location, geometry and management, the study identified six categories of olive multi-use landscapes (ibid., p. 54): inland and coastal plains; lower foothills; upper foothills; ravines; village peripheries; urban and suburban. The categories are an indication of the adaptability of these traditional landscapes to varied physical settings, changing socio-economic conditions and modernizing processes (Fig. 9.16). Accepting olive production as one indication of extent, the total production for the region surveyed was estimated at 2,220,000 tons, with the highest production in the Karpasia Peninsula and Ammochostos province, 1,247,000 tons. The total number of olive trees for the same period in 1995 was estimated at 521,848. Cheap olive oil imports from mainland Turkey, the study found, is a key threat to olive production in the regions surveyed. Declining profitability undermines the value of these traditional landscapes and eventually leads to their destruction.

Fig. 9.16 View of carob (foreground) and olive (orthogonal planting) trees in the Kyrenia Range that reflect the versatility of layout and response to climate and landform (Photo courtesy of J. Makhzoumi) (*See Colour Plates*)

Traditional landscapes are also threatened by the constant rise in urban population and growing commercial and tourist development (Makhzoumi and Pungetti 1999). While modernizing processes, namely around the capital Lefkosia and in the coastal plain, fragment and homogenize, rural poverty and agricultural abandonment indirectly undermine the ecological and cultural integrity of the traditional rural landscape. Awareness of the threats to traditional landscapes in Cyprus is reflected in a number of initiatives to protect the island's rural cultural heritage. The Laona Foundation is one such initiative, which promotes eco- and agri-tourism in five villages on the border of the Akamas Reserve (Cyprus Conservation Foundation 2006). Similarly, there is a move towards alternative approaches to nature conservation (Section 9.6). The latter reflect a clear broadening of past emphasis on the productivity and the strictly economic benefits of the forest to valuation that includes environmental and ecological benefits and prioritizes on biodiversity and endemism (Section 9.3). The shift should necessarily be complemented with similar initiatives that aim to protect the mosaic that constitutes the regional landscape in Cyprus, equally as a natural and cultural heritage.

Without comprehensive, island-wide landscape planning, however, the impact of these initiatives will be limited. Future planning should accept that traditional landscapes in the predominantly hill terrain of Cyprus have non-economic values due to 'their combined bio-socio-ecological ecosystem functions for which no alternative is available' and also because their loss would be irrevocable (Naveh 1982). Attempts to conserve the traditional Mediterranean landscape will need to recognize the ecological, environmental and cultural significance of the landscape mosaic as a starting point. Equally it is necessary to accept human agency as integral to the historical development of the island landscape and a key to maintaining landscape heterogeneity and the high species diversity. Nor should the aesthetic value of the traditional rural landscape be ignored. The regional landscape mosaic provides the Mediterranean 'image' which, among other assets, is a key in marketing tourism in Cyprus as in all Mediterranean Islands.

9.5 Recent Environmental Changes

The milestones that heralded significant changes for the environment of Cyprus can be set in 1878 when Britain assumed the administration of the island; in 1960, when Cyprus became an independent republic; and in 1974, when, after 10 years of unrest, Turkey invaded Cyprus and occupied one third of the island. The main changes in the landscape regarding land-use patterns are illustrated in Table 9.3 and they are related mainly to the trends of economy, but also to changes in the attitude of people towards nature. Under the British administration, the efforts to conserve the then devastated forest resource started. The extent and composition of the forests was recorded and assessed, the first Forest Law was issued and the Forestry Service established. At the onset of the 20th century, an economically and socially retrogressive island, after 300 years of Ottoman rule, was on a slow path to development and the process towards rational forest resource and land management was extremely slow.

The British administration inherited the problems of extensive deforestation and soil loss which were widespread well before the World Wars (Lowdermilk 1948; Jenness 1962; Thirgood 1981). World War I was destructive for the forests and a set back for the implementation of forest policy, but overcutting, overgrazing and firing in peace time were even more destructive. The juniper forests of Cavo Greco and Paralimni were destroyed in the inter-war period, surface soil was washed away and the underlying limestone exposed over the entire area (Thirgood 1987). However, by 1939, illicit grazing and incendiarism had been greatly reduced, new laws established and the public were beginning to appreciate the value of forests. Cyprus just prior to World War II was unique in the Middle East for possessing extensive areas of natural forest (Thirgood 1987). During World War II there was no cutting without control and there came the long demanded conversion from wood to oil fuel. As a result, forests emerged in better condition than ever. Up to 1960, great progress was made, despite the fires caused during the political unrest after 1955. The idea then was that *In Cyprus forests were needed not only for soil and water conservation but also for timber production* (Thirgood 1987). Much effort was put into reforestation and tree plantations and also on the development of a dependable method of regenerating the forest.

In 1960, with the establishment of the independent Republic of Cyprus, the newly formed government accelerated the upgrading of economic and social infrastructure. Part of this involved the shift from an agricultural economy to a mainly secondary and tertiary sector economy (Press and Information Office of Cyprus 2001). Besides, the end of the decade brought the explosion of tourism (Pasiardis et al. 2002). Nevertheless, the favourable trends of public attitude and government policies towards forests were continued and strengthened and there was a change towards withdrawing forest land from production and development for recreational purposes (Thirgood 1987). Finally, with the motto 'no drop of water to the sea', there was extended water engineering activity which resulted in an increase in freshwater storage capacity from 6 million m^3 to 300 million m^3 (WDD-FAO 2002). The mass construction of reservoirs and storage basins altered the landscape locally and reduced the riparian forests and ground aquifer recharge downstream but also created a new and unique freshwater habitat (Delipetrou 2004).

The war and Turkish invasion in 1974 brought catastrophic fires which destroyed nearly 17% of the total forest land and divided the island in two parts the development of which progressed at different rates and in different directions (Ayres 2004). In the southern part, the area under the government of the Republic of Cyprus, the trends established in 1960 continued. A large restocking programme, with extended bulldozing and terracing, resulted in the reforestation of all burnt forests by 1982 (Thirgood 1987). However, the movement of one fourth of the population along with the loss of the most productive and developed part of Cyprus (Della 1998) made the need for tourism development pressing (Pasiardis et al. 2002). Thus, the southern part suffered a heavy toll from overpopulation, vigorous building activity and rapid expansion of tourism which altered the lowland and especially the coastal landscape quickly and irrevocably while more land for development is in constant demand (Pantelides 2001; Pasiardis et al. 2002; Department of Forests 2005).

It is difficult to estimate the recent loss of coastal dune and marsh habitat since no pre-1982 inventory exists. A fact indicative of the extent of sandy habitat destruction is the case of *Ammophila arenaria*. This plant, which was once the most widespread and important sand-binder and *abundant at the sandy expanses of Agia Napa* (Holmboe 1914), has now become very rare and endangered (Hadjichambis 2005), and is restricted to only one remnant population near Agia Napa.

Yet, since the last decade of the 20th century, growing environmental concern and the accession to the EU have directed the state planning towards controlled and sustainable management of the natural resources. Sustainable development goals were incorporated in the Strategic Development Plans for the periods 1994–1998 and 1999–2003 while environmental legislation was reformed in order to adopt the European law and regulations. The land-use zones established by the Town Planning Department (Department of Urban Planning and Habitation 1996), the characterization of main and minor forests (including Forest and Nature reserves and National Parks) established by the Forestry Department (Forest Regulations 1967–1991), and the Marine Reserves and Protected Areas, established by the Fisheries and Marine Research Department, are important tools for landscape shaping and conservation.

In contrast, in the occupied northern part, agriculture remained a main activity (SPO 2003) and, until recently, the coasts had been left undisturbed. Despite the gradual arrival of over 100,000 settlers from Turkey, there was no increase in urban settlements, since they inhabited the existing built-up areas. Moreover, several cultivated fields were abandoned and left to a natural succession of vegetation establishment. Notably, at the abandoned and uninhabited city of Ammochostos (Famagusta), which had been the first coastal area to develop in the pre-invasion years, nature has got its own way for thirty years now and the coasts constitute an example of the potential for natural habitat re-establishment. During the last decade, the effort for economic growth initiated a trend for tourism development along with a decline of the agricultural sector (USAID 2001; SPO 2003) which will undoubtedly mark significant changes to the landscape. Moreover, since 2003, there has been an outbreak of road and mass building construction (Stavri 2005). The coastal development, especially at the areas of Kyrenia and of Salamina to Karpasia, is a red alert for the sand dune systems which can be saved by the implementation of sustainable development policies.

The main environmental issues influencing the current, post-1974, landscape trends in Cyprus pertain to the management of the forest and water resources, soil erosion and habitat degradation caused by tourism, agricultural and industrial development. Water availability presents an acute problem especially due to reduced precipitation over the last 30 years (Rossel 2001) and due to over-consumption caused by improved living standards, wasteful use of water, population increase and movement towards the urban centres. The groundwater resources are overexploited by 40% of sustainable extraction (WDD-FAO 2002) and there is ground aquifer salinization (Georgiou 2002). These problems are now being tackled by the use of desalinization plants, water recycling, construction of dams for aquifer recharge (UN 2002) and recent water legislation changes (implementation of the EU Water Framework Directive and the Nitrate Directive).

The forest resources, especially coniferous forests, are well conserved and expanding and the National Forest Programme of 2000 is based on the principles of multiple use and sustainability (UN 2002). Deforestation may be caused by drought and by successive fires and there are also pressures for land reclamation (Department of Forests 2005). However, fires, although a constant threat and cause of damage, are quite effectively counteracted, especially in state forest land (Hadjikyriakou 2000). Moreover, the decline of agricultural activities in favour of the tertiary sector, results in natural shrub and forest regeneration (see Box 9.1). On the other hand, grazing although quite effectively controlled in state forest land is destructive when it follows burning (Department of Forests 2005). Overgrazing has an intense impact in the shrub vegetation of certain rural areas where desertification is possible. Riparian forests, mainly due to drought, water management and land reclamation, but also due to grazing and land management for grazing, are in retreat and their protection has only recently drawn attention.

Soil and water pollution in the form of industrial waste, agricultural chemicals, livestock production effluent and urban sewage and solid waste present a growing problem. Indicatively, nitrate levels increased from 1970 to 2001 (Hydrogeological Services International Ltd. and Geoinvest Ltd. 2002; State General Laboratory, Ministry of Health, Cyprus 2000). Soil loss has not been exacerbated in the last few decades but it remains a problem, endogenous in the Mediterranean landscape, especially on calcareous soils (Hadjiparaskevas 2001). In Cyprus, soil erosion is mainly caused by unsustainable agricultural practices (EEA 2002) and land management

(Hadjiparaskevas 2001), but it may also be due to the special character of the substrate, as on the serpentines of Troodos (Noller 2005). The recent intensification of soil monitoring and the implementation of the EU Common Agricultural Policy (CAP) and of the Convention to Combat Desertification are expected to help erosion control.

The mining industry has been in decline for the last three decades, with only one currently active mine, the Skouriotissa Copper mine (MANRE 2005a) and there is an effort for rehabilitation of the old mines (Kyrou and Petrides 2005). However, there is extensive quarrying of rocks and industrial minerals with c.220 quarries producing various materials and producing heavy impacts to the landscape.

Tourism remains a vital sector for the economy of Cyprus (Blake et al. 2003) and tourist arrivals have been following an increasing trend since 1996 (Pasiardis et al. 2002). In addition, Cyprus is being promoted as a place of permanent residence for foreigners. As a result, there is heavy pressure for further property development at the coastal areas which means further loss and fragmentation of sand dune and shingle and maritime shrub habitats. Moreover, construction activities have started to expand towards the lowland hills (e.g. Agia Napa, Pafos) while trampling, uncontrolled 4 × 4 vehicle expeditions, golf course establishments, beach shaping and cleaning cause further natural habitat degradation. On the other hand, the 'overdependence' of the economy on tourism in parallel with its negative effects both on the natural environment and the quality of life (congestion, criminality increase, increased water consumption, etc.) have triggered a change of policy towards an emphasis on quality rather than on quantity and the search for alternative forms of tourist development such as agro-tourism (Pantelides 2001; Pasiardis 2002). The proposed fundamental restructuring of the Cyprus economy in the direction of expanding and modernizing the productive sectors (Pantelides 2001) might resolve the conflict between sustainable development and economic progress.

9.6 Landscape Conservation

Nature protection in Cyprus has been subject to legislation and measures since the early 1960s (Environment Service 2005). Landscape conservation had principally been a matter of the forest resource management, town and country planning and the combat of soil erosion until the 1980s. The concept of protected areas appeared in the revised Forest Law of 1965–1967 which classified the Forest Estate in Main State Forests including Permanent Forest Reserves, National Parks and Nature Reserves and in Minor State Forests including multiple use forests, municipal and communal forests, nursery gardens and grazing areas (Forest Law 14/1967). In the 1980s another 2,000 ha of wastelands of hills and lowlands were brought under Forestry control (Cyprus Forest Department 1985). During the 1980s and 1990s environmental policy entered the strategic development plans of the island and in 1990s sustainable development was incorporated in political decision-making while during the period of the accession to the EU national legislation was harmonized with the European environmental law and with international conventions (EEA Report).

What is most important for conservation at landscape level, today environmental issues in Cyprus are dealt with through an integrated decision-making process. Overall environmental policy is formulated by the Council of Ministers and coordinated through the Minister of Agriculture (MANRE), Natural Resources and Environment (with the exception of town and country planning issues) who is advised by the Council of the Environment. The Environment Service of MANRE is mandated to advise on environmental policy and to coordinate and ensure the adoption of the EU environmental policy and legislation. Interministerial cooperation is ensured by the participation of all three competent authorities in almost all bodies established under the environmental management system, the physical planning system and the national development planning and control system (EEA Report).

Except for the aforementioned Forest Law and the physical planning regulations (Department of Town and Country Planning 1996), environmental protection is mainly based on the Law on the Protection and Management of Nature and Wild Life (No.153(I)/2003; adoption of the EU Habitats' Directive), Law on the Protection and Management of Wild Birds and Game (No. 152(I)/2003; adoption of the EU Birds' Directive), the Fisheries Law (No. 61 (I)/2001; coastal and marine areas), the law on the introduction of genetically modified organisms (No. 160(I)/2003, EU Directive 2001/18/EC), the legislation on Environmental Impact Assessment of certain Projects (No. 57(I)/2001) and of Plans and Programmes (No. 102(I)/2005) (Environment Service 2005). Finally, sustainable agriculture, including the integration of biological and landscape diversity, is promoted by the Rural Development Plan, for the implementation of the relevant EU regulations and partly financed by the EU (Environment Service 2005). It must be noted that the above legal framework as well as the implementation of the EU *aquis* currently apply only to the area under control of the Republic of Cyprus. There are however UNEP programmes which promote cooperation on environmental issues between the Greek-Cypriot and Turkish-Cypriot communities.

A series of Natural Reserves and National Forest Parks (Table 9.4) including natural forests and arboreal shrubs as well as afforested areas have been designated since 1980 (database BIOCYPRUS). The Permanent Forest Reserves are larger forest land areas with a strict protection which however allows for more human activities and they include the huge forested area of Pafos forest, the reforested area of Stavrovouni, etc. It is notable that the peninsula of Akamas with three permanent forest reserves is managed as a National Park despite the fact that due to conflicting interests the area has not been declared as one. It should also be pointed out that the designation of minor forests has also been important for landscape management. The communal forests, which belong to village communities or town municipalities and were established mainly for the provision of fuel wood, when these needs ceased to exist, were mostly converted to parks or recreation grounds (Environment Service 2005).

Among the most important coastal and marine protected areas are the National Marine Reserve of Lara-Toxeftra (an important sandy beach for sea turtles at Akamas) and the Ramsar Wetlands of the salt lakes of Alyki Larnakas and of Akrotiri. All the three sites are also Barcelona Convention Special Protected Areas (UNEP Directory).

Table 9.4 National Forest Parks and Nature Reserves in Cyprus

Protected area	Area (ha)	Landscape elements
National Forest Parks		
Troodos NFP	9,307	Natural Aegean pine and black pine forests, golden oak and mountain juniper stands, riparian and spring wetlands, screes
Cavo Greco	390	Phoenicean juniper stands, coastal rocks, forest plantations
Petra tou Romiou		Mediterranean maquis and phrygana, pine forest, coastal rocks
Potamos tou Liopetriou	89	Forest plantations and vernal pools, phrygana, river estuary
Athalassa	840	Suburban forest plantations
Paedagogical Academy	45	Suburban forest plantations
Polemidia	125	Mediterranean maquis and forest plantations
Rizoelia	97	Forest plantations and few gypsophilous vegetation patches
Nature Reserves		
Tripylos	823	Cedar forest
Mavroi Kremmoi	2,558	Pine forests, golden oak stands, riparian wetlands, rocks with chasmophytes
Madari	1188	Mountain peak with aegean pine and black pine forest, mountain juniper stands, rocks with chasmophytes
Troodos reserves (4)	220	Riparian wetland, mountain peak, eroded and forested slopes

The regulations of the Town and Country Planning Department (1996) have played an important role for landscape management as they have delimited development zones and protected areas and applied rules regarding physical planning and building which are not only strictly enforced but also generally widely accepted by the public. The protected landscapes include dams, mountain peaks, cliffs and ravines, geological formations, archaeological sites and villages with special social, architectural or historical interest or character. The monitoring and management of water bodies, especially rivers, which function as ecological corridors at landscape level, will be planned according to the Water Framework Directive 2000/60/EC which was recently incorporated in the legislation of Cyprus (Law No. 3812/2004) and will enforce the existing Law 82/30 for Public Rivers Protection.

At the beginning of the 21st century, the NATURA 2000 network, the main tool for the conservation of biodiversity in the EU, has also become of central importance for environmental protection in Cyprus. The EU Habitats' Directive and Birds' Directive mandate the delimitation of sites in which habitat conservation ensures species conservation and for which monitoring and management plans should be implemented. A first list of 39 proposed Sites of Community Importance (SCIs) and Special Protection Areas (SPAs) was prepared by a LIFE project and all the relevant data compiled in a database BIOCYPRUS (MANRE and University of Athens 2001). This list (Table 9.5) intended to cover the island as a whole and included sites in the occupied part of Cyprus and also sites of British Sovereign bases. In the period 2002–2005 political deliberations and consultations with the

Table 9.5 Proposed NATURA 2000 sites and of sites currently included in the National List of Proposed SACs (From BIOCYPRUS 2006)

SITE name (SCIs)	SPA	SACs
Periochi Agias Eirinis – Kormakiti		
Oroseira Pentadaktylou		
Periochi Alakati		
Mammari – Deneia		√
Alykos Potamos – Agios Sozomenos		√
Periochi Mitserou		√
Dasos Machaira		√
Madari – Papoutsa		√
Dasos Pafou**	√	√
Periochi Platy*		√
Koilada Kedron – Kampos*		√
Giouti – Periochi Pachyammou		
Akrotirio Apostolou Andrea – Nisoi Kleides		
Akrotirio Elaia – Limanouri		
Salamina – Limnes Ammochostou		
Kavo Gkreko		√
Thalassia Periochi Nisia		√
Paralimni Lake*		√
Periochi Polis – Gialia		√
Cha-Potami		√
Koilada Diarizou		√
Vouni Panagias	√	√
Episkopi Morou Nerou		√
Thalassia Periochi Moulia		√
Xeros Potamos	√	√
Mavrokolympos		√
Periochi Skoulli		√
Chersonisos Akama		
Periochi Agiatis*		√
Periochi Stayros Tis Psokas – Karkavas*		√
Faros Kato Pafou*	√	√
Dasos Lemesou		√
Alyki Akrotiriou – Ygroviotopos Fasouriou		
Periochi Episkopis		
Ethniko Dasiko Parko Troodous	√	√
Akrotirio Aspro – Petra Romiou	√	√
Koilada Limnati	√	√
Periochi Asgatas	√	√
Kavo Pyla	√	
Alykes Larnakas	√	√
Periochi Lympion – Agias Annas		√
Dasos Stavrovouniou		√
Periochi Lefkaron		√
Ethniko Dasiko Parko Rizoelias		√

*Sites not included in the Life Project proposal; **Sites in national list only as an SPA.

local communities produced the official National List of proposed Special Areas of Conservation (including both SCIs and SPAs) which does not include areas not controlled by the Republic of Cyprus.

This list is still not finalized since for some areas such as Akamas the delimitation of the protected sites is pending. The preparation of management plans for the proposed sites is already under way. As the proposed sites include most of the other protected sites of Cyprus the NATURA 2000 network will act as an umbrella network for nature protection in Cyprus. Most importantly, the integrated management of sites, rather than of individual species or habitats, is an important development for landscape conservation.

References

Andreou, M. and Panagiotou, A. (2004) Bioclimatic characterization (according to Rivas-Martínez) of certain areas of Greece and Cyprus. Laboratory Project for the Course of Ecophysiology, Botany Department, University of Athens.

Argyrou, M. (2000) Monitoring program on the impact of the concentrate on the marine environment, Cyprus, Phase I, –Background data –. Ministry of Agriculture, Natural Resources and Environment, Department of Fisheries and Marine Research Report, pp. 53.

Argyrou, M., Hadjichristophorou, M. and Demetropoulos, A. (1999) Ecological changes of soft-bottom macrobenthic assemblages in relation to the sewage outfall, in the Limassol bay, Cyprus, Eastern Mediterranean. Oebalia XXV: 61–88.

Ayres, R. (2004) The economic costs of separation: the north–south development gap in Cyprus. Wolfson College Workshop: Investment and Finance in Northern Cyprus, 22 October 2004.

Barber, I. and Valles, A. (1995) Contribution to the knowledge of the bioclimate and vegetation of the island of Cyprus. Post Diploma Course in Forestry. Cyprus Forestry College, Nicosia, 37 pp.

Barbéro, M. and Quézel, P. (1979) Contribution à l' étude des groupments foréstiers de Chypre. Documents phytosociologiques, Lille, IV: 9–34 + 1 Tab.

Bate, D.M.A. (1904) Further note on the remains of *Elephas cypriotes* from a cave-deposit in Cyprus. Philosophical Transactions of the Royal Society of London B 197: 347–360.

Binford, L. (2000) Faunal extinction in an island society (Book Review). American Antiquity 65: 771.

Blake, A., Sinclair, M.T. and Sugiyarto, G. (2003) Tourism and EU accession in Malta and Cyprus. Presentation at the 'Tourism Modelling and Competitiveness: Implications for Policy and Strategic Planning' Conference, 31 October–1 November, Paphos, Cyprus.

Blondel, J. and Aronson, J. (1999) Biology and Wildlife of the Mediterranean Region. Oxford University Press: New York.

Blosat, B. (1998) Morphologie, Aut- und Populationsökologie einer Reliktpopulation der zypriotischen Rigelnatter, *Natrix natrix cypriaca* (Hecht, 1930). Ph.D. thesis, University of Bonn, 174 +15 pp.

Böhme, W. and Weidl, H.J. (1994) Status and zoogeography of the herpetofauna of Cyprus, with taxonomic and natural history notes on selected species (genera *Rana, Coluber, Natrix, Vipera*). Zoology in the Middle East 10: 31–52.

Bottema, S. (1966) Palynological investigations of a settlement near Kalopsida (Cyprus). In P. Aström (ed.) Studies in Mediterranean Archaeology II. Excavations at Kalopsida and Agios Iakovos in Cyprus. Lund, pp. 133–134.

Christodoulou, C.S. (2003a) The impact of *Acacia saligna* invasion on the autochthonous communities of the Akrotiri salt marshes. B.Sc. thesis, Forest Management Department of Forestry, University of Central Lancashire, 96 + viii pp.

Christodoulou, C.S. (2003b) I chlorida tou Ethnikou dasikou Parkou Troodous (The flora of Troodos National Forest Park). Unpublished manuscript, submitted to the Forestry Department, Ministry of Agriculture, Natural Resources and Environment of Cyprus.

Christodoulou, D. (1959) The Evolution of the Rural Land Use Pattern in Cyprus. Geographical Publications: London. Commissioned by ProAction and Middle East Environmental Ltd., Nicosia.

Council of Europe (1992) Council Directive 92/43 EEC of 21 May 1992 on the Conservation of Natural Habitats and Wild Fauna and Flora. O.J. Eur. Comm. No. L206/7: 7–50.

Croft, P.W. (2002) Game management in early prehistoric Cyprus. Zeitschrift Für Jagdwissenschaft 48: 172–179 suppl.

Cyprinia (2005) Project: the red data book of Cyprus Flora – Cyprinia. Institute of Research Promotion of Cyprus, 2002–2006.

Cyprus Flora (2005) Database of the flora of Cyprus, compiled by P. Delipetrou and K. Georghiou, based on work by C. Kadis, G. Hadjikyriakou and C.S. Christodoulou. Cyprus Conservation Foundation (2006) The Laona Foundation (http://www.conservation.org.cy/laona/laona.htm).

Cyprus Forest Department (1985) Progress report 1980–1984 by the Forestry Department of the Republic of Cyprus, prepared for the 12th Commonwealth Forestry Conference.

Daget, P. (1977) Le bioclimat méditerranéen: caractères généraux et modes de caractérisation. Vegetatio 34: 1–20.

Davies, P.A. and Lister M. (2001) *Palaeoloxodon cypriotes*, the dwarf elephant of Cyprus: size and scaling comparisons with *P. falconeri* (Sicily-Malta) and mainland *P. antiquus*. In: The World of Elephants – International Congress, Rome 2001, pp. 479–480.

Davis, S.D., Heywood, V.H. and Hamilton, A.C. (eds.) (1994) Centres of Plant Diversity. WWF/IUCN: Cambridge.

Delipetrou, P. (2004) Type specific reference conditions for rivers and lakes. In: Implementation of Articles 5 & 6 of the Water Framework Directive 2000/60/EC. Specialised consultancy services under contract No. 39/03/61 with MANRE Water Development Department of Cyprus for the establishment of type-specific reference conditions. Final Report. WL Delft hydraulics, ENVECO SA, D. Argyropoulos & Associates.

Delipetrou, P. and Georghiou, K. (2000). The endemic plants of Greece: Who, Where and How are they? MEDECOS 2000. 9th International Conference on Mediterranean – Type Ecosystems, p. 20, Stellenbosch, South Africa.

Della, A. (1998) International Conference and Programme for Plant genetic Resources (ICPPGR). Country Report for Cyprus. FAO (http://web.icppgr.fao.org).

Department of Forests (2005) National Report to the Fifth Session of the United Nations Forum of Forests, 19 p.

Department of Town and Country Planning (1996) Policy Statement. Policy for the regulation and control of development and the protection of the environment in the country and in the villages. Ministry of Interior, Republic of Cyprus, 201 p. (in Greek).

Department of Urban Planning and Habitation (1996) Dilosi Politikis. Politiki gia ti rythmisi kai ton elencho tis anaptyxis kai tin prostasia tou perivallontos stin ypaithro kai ta choria. (Policy Statement. Policy for the regulation and the control of development and the protection of the environment in the country and in the villages.) Ministry of Environment, Republic of Cyprus, Lefkosia, 201 p. + 1 map.

Dewar, R. (2001) Faunal extinction in an island society (Book Review). American Anthropologist 103: 229–230.

EEA (2002) Assessment and Reporting on Soil Erosion. European Environmental Agency: Copenhagen.

Emberger, L. (1930) Sur une formule applicable en géographie botanique. Comptes rendus de l'Académie des sciences. La vie des sciences 191: 389.

Environment Service (2005) 1st National Report for the Convention of Biological Diversity.

Forest Regulations (1967–1991) Official Gazette of the Republic. Part III 28.7.1967; Part III(1) 4.11.1988, 15.3.1991.

Forestry Department, Ministry of Agriculture, Natural Resources and Environment of Cyprus (2004) GIS Map of the Vegetation of Cyprus.

Forestry Department, Ministry of Agriculture, Natural Resources and Environment of Cyprus (2005) (http://www.moa.gov.cy/moa/fd/fd.nsf/DMLflora_gr).

Georgiou, A. (2002) Assessment of Groundwater Resources of Cyprus. Reassessment of the Island's Water Resources and Demand WDD/Fao. TCP/CYP 8921.

Göçmen, B. and Böhme, W. (2002) New evidence for the occurrence of the dice snake, *Natrix tessellata* (Laurenti 1768) on Cyprus. Zoology in the Middle East 27: 29–34.

Guilaine, J. and Briois, F. (2001) Parekklisia-Shillourokambos: An early Neolithic site in Cyprus. In: S. Swiny (ed.) The Earliest Prehistory of Cyprus. From Colonization to Exploitation. Cyprus American Archaeological Research Institute Monograph Series, Vol. 2. American Schools of Oriental Research archaeological Reports, Boston, MA, ISBN 0-89757-051-0, pp. 37–54.

Hadjichambis, A. Ch. (2005) Conservation biology of threatened coastal habitats of Cyprus: flora, vegetation, ecology and management. Ph.D. thesis, Department of Biology, University of Athens, Athens, 548 p. (in Greek).

Hadjikyriakou, G. (1997) I chlorida tis Kyprou mesa apo katalogous kai pinakes (The flora of Cyprus through lists and Tables). Private Publication, Cyprus, 232 p.

Hadjikyriakou, G. (2000) The forest fire situation in Cyprus. Int. Forest Fire News 23: 71–76.

Hadjiparaskevas, C. (2001) Soil Survey in Cyprus (Options Méditerranéennes: Série B. Etudes et Recherches; n. 34), pp. 101–114, ISBN 2-85352-227-X.

Hadjisavvas, S. (1992) Olive Oil Processing in Cyprus. From the Bronze Age to the Byzantine Period. Paul Astroms Forlag: Nicosia.

Hadjisterkotis, E. (ed.) (1996) The Mediterranean mouflon: management, genetics and conservation. Abstracts of the Second International Symposium on Mediterranean mouflon. Government Printing Office, Nicosia, pp. 42.

Hadjisterkotis, E. (2001) Datasheet, *Rousettus aegyptiacus*. Proposal for the Habitat Directive (92/43/EEC), Annex 1, by Cyprus.

Hadjisterkotis, E. and Bider, J.R. (1997) Cyprus. In: D.M. Shackleton (ed.) and the IUCN Caprinae Specialist Group. Wild Sheep and Goats and their Relatives, Status Survey and Conservation Action Plan for Caprinae. Information Press: Oxford, pp. 89–92.

Hansen, J. (2001) Aceramic Neolithic plant remains in Cyprus: Clues to their origins? In: S. Swiny (ed.) The Earliest Prehistory of Cyprus. From Colonization to Exploitation. Cyprus American Archaeological Research Institute Monograph Series, Vol. 2. American Schools of Oriental Research archaeological Reports, Boston, MA, ISBN 0-89757-051-0, pp. 119–128.

Holmboe, J. (1914) Studies on the vegetation of Cyprus. Bergens Museums Skrifter, NY Raekke, Bind I. No 2, Bergen, 344 p.

Hutchins, D.E. (1909) Report on Cyprus Forestry. Waterlow: London, 93 p.

Hydrogeological Services International Limited and Geoinvest Ltd. (2002) Study of the protection of waters caused by nitrates from agricultural sources according to the Directive 91/676/EEC Contract No. GSD/11/2000. Final Draft Report, MANRE Geological Survey Department, Republic of Cyprus, 73 p.

Iezekiel, S. (2001) I kypriaki panida (The cyprian fauna). In: Notio Aigaio – Kriti – Kypros. Synergasia gia to perivallon kai tin anaptyxi (South Aegean – Crete – Cyprus. Cooperation for the environment and development). Natural History Museum of Crete, Irakleio ISBN 960-367-010-3, pp. 103–111 (in Greek).

IUCN, World Conservation Monitoring Centre (1993) Cyprus: Conservation Status Listing of Plants. WCMC: UK.

Jenness, D. (1962) The Economics of Cyprus. A Survey to 1914. McGill University Press: Montreal, 219 + x p.

Jones, D.K., Merton, L.F.H., Poore, M.E.D. and Harris, D.R. (1958) Report on Pasture Research, Survey and Development in Cyprus. Including pasture survey map produced in 1932, revised in 1952. Government of Cyprus.

Karali, L. (1996) Palaioperivallontiko yliko apo ti neolithiki thesi Kantou-Koufovounos tis Kyprou (Paleoenvironmental material from the neolithic site Kantou-Koufovounos of Cyprus). In: The excavation report of E. Mantzourani at the Kantou-Koufovounos site from 1994 to 1995. Epistimoniki Epetirida tou Tmimatos Arxaiotiton, Nicosia (in Greek).

Keswani, P.S. (1994) The social-context of animal husbandry in early agricultural societies – ethnographic insights and an archaeological example from Cyprus. Journal of Anthropological Archaeology 13: 255–277.

Kyrou, K. and Petrides, G. (2005) The Rehabilitation of the Asbestos Mine, Cyprus, Politikos Michanikos.

Lowdermilk, W.C. (1948) Conquest of the Land Through Seven Thousand Years. US. Department of Agriculture, Soil Conservation Service.

Madon, P.G. (1881) Forest conservancy in the island of Cyprus. Reprinted at the Government Printing Office, Nicosia, Cyprus 1930, 28+46 p.

Makhzoumi, J. (1997) The changing role of rural landscapes: olive and carob multi-use tree plantations in the semiarid Mediterranean. Landscape and Urban Planning 37: 115–122.

Makhzoumi, J. (2001) Olive Trees: Inventory and Assessment. Unpublished report.

Makhzoumi, J. and Gunduz, S. (2002) Nature conservation in the Mediterranean: new roles for traditional rural landscapes. In H. Gokcekus (ed.) Environmental Problems of the Mediterranean Region, Nicosia, International Conference 12–15 April, Nicosia, Cyprus.

Makhzoumi, J. and Pungetti, G. (1999) Ecological Landscape Design and Planning. The Mediterranean context. E & FN Spon: London.

MANRE and University of Athens (2001) Special areas of conservation (Directive 92/43/EEC) in Cyprus (1999–00) EU DG XI, Life Third Countries (B4 - 0000/98/000). Final Report and database BIOCYPRUS.

MANRE (2005a) Annual report of the Ministry of Agriculture, Natural Resources and Environment for 2004 (English summary). Nicosia, 93 p.

MANRE (2005b) CORINE Land Cover 2000 (CLC2000) Cyprus. Grant Agreement Ref. No. 3412-B2004.EEA.51822. Final Report. Ministry of Agriculture, Natural Resources and Environment of Cyprus, Lefkosia, 20 p.

Meikle, R.D. (1977) Flora of Cyprus. Vol. 1. The Bentham – Moxon Trust Royal Botanic Gardens, Kew.

Meikle, R.D. (1985) Flora of Cyprus. Vol. 2. The Bentham – Moxon Trust Royal Botanic Gardens, Kew.

Meteorological Service, Ministry of Agriculture and Natural Resources (1986) The climate of Cyprus. Republic of Cyprus, Lefkosia, Cyprus, ISBN 9963-1-8012-1, 72 p. (in Greek).

Naveh, Z. (1975) Degradation and rehabilitation of Mediterranean landscapes. Landscape Planning 2: 133–146.

Naveh, Z. (1982) Mediterranean landscape evolution and degradation as multivariate biofunctions: theoretical and practical implications. Landscape Planning 9: 125–146.

Noller, J.S. (2005) Serpentinite soil ecology on Cyprus: a reappraisal of a Foundation of the Soil Erosion Paradigm. Proceedings of the Pacific Division of the American Association for the Advancement of Science 24(I): 75–76.

Olsen, S. (1999) Investigation of the *Phanourios* bones for evidence of cultural modification, chapter 9, specialized analysis, section 5. In A.H. Simmons (ed.) Faunal Extinction in an Island Society: Pygmy Hippopotamus Hunters of Cyprus. Plenum Press: New York, pp. 230–237.

Palamarev, E. (1987) Paleobotanical evidences of the Tertiary history and origin of the Mediterranean sclerophyll dendroflora. Plant Systematics and Evolution 162: 93–107.

Pantelas, V.S. (1996) The Cyprian bioclimate and the climax plant associations. Proceedings of the 6th Scientific Conference of Hellenic Botanical Society, Paralimni Cyprus, April 1996.

Pantelides, P. (2001) Public Policies and institutional context for a sustainable model of economic development in Cyprus. In Report on the EIC One Day Conference 'Sustainable development and environmental policy in Cyprus: adopting and implementing EU legislation', April, 2001 Nicosia.

Pasiardis, P., Nearchou, P., Mitsis, P. and Panteli, P. (2002) Paragogikotita, timi kai poiotita tou kypriakou touristikou proiontos: Sygkrisi me alles mesogeiakes chores (Productivity, price and quality of the cyprian tourism product: Comparison to other Mediterranean countries). University of Cyprus, Economic Research Center, 181 p.

Pignatti, S. (1995) Flora. In S. Pignatti (ed.) Ecologia Vegetale. UTET, Torino, ISBN 88-02-04670-0.

Press and Information Office of Cyprus (2001) About Cyprus. Economy. Republic of Cyprus, Lefkosia, 462 p., ISBN 9963-38-242-8.

Quézel, P. and Barbéro, M. (1985) Carte de la vegétation potentielle de la région mediterranéenne. I. Mediterranéenne Orientale. Ed. C.N.R.S, Paris, 69 p. + carte.

Raus, T. and Scholz, H. (2004) Contribution to the flora of Cyprus: a new species of Crypsis (Poaceae). Willdenowia 34: 457–462.

Reese, D.S. (2001) Some comments on the Akrotiri-Aetokremnos fauna. In: S. Swiny (ed.) The Earliest Prehistory of Cyprus. From Colonization to Exploitation. Cyprus American Archaeological Research Institute Monograph Series, Vol. 2. American Schools of Oriental Research Archaeological Reports, Boston, MA, ISBN 0-89757-051-0, pp. 19–36.

Rivas-Martínez, S., Penas, A., Luengo, M.A. and Rivas-Sáenz, S. (2004) Worldwide Bioclimatic Classification System (http://www.globalbioclimatics.org).

Rossel, F. (2001) Hydrometeorological study examining changes in recorded precipitation. Reassessment of the island's water resources and demand. Objective 1 – Output 1.2. Ministry of Agriculture, Natural Resources and Environment of the Republic of Cyprus Water Development Department, Food and Agriculture Organisation of the United Nations Land and Water Development Division, TCP/CYP/8921.

Samways, M.J. (lead author) (1995) Magnitude and distribution of biodiversity: endemism and biodiversity. In: V.H. Heywood and R.T. Watson (eds.) Global Biodiversity Assessment. Cambridge University Press: Cambridge, pp. 174–191, ISBN 0-521-56481-6.

Schiller, G., Shklar, G. and Korol, L. (2004) Genetic diversity assessment by random amplified polymorphic DNA of oaks in Israel. 2. Quercus boissieri Reut. Isr. Journal of Plant Science 52: 315–322.

Simmons, A.H. (1999) Faunal Extinction in an Island Society: Pygmy Hippopotamus Hunters of Cyprus. Kluwer/Plenum: New York, 381 + xxi p., ISBN: 0-306-46088-2.

Simmons, A.H. (2001) The first humans and the last pygmy hippopotami in Cyprus. In: S. Swiny (ed.) The Earliest Prehistory of Cyprus. From Colonization to Exploitation. Cyprus American Archaeological Research Institute Monograph Series, Vol. 2. American Schools of Oriental Research archaeological Reports, Boston, MA, ISBN 0-89757-051-0, pp. 1–18.

Smith, M. (2000) Faunal extinction in an island society: pygmy hippopotamus hunters of Cyprus (Book Review). Australian Archaeology 54: 67–68.

SPO (2003) Turkish Cypriot State Planning Organisation (www.devplan.org).

State General Laboratory, Ministry of Health, Cyprus (2000) Development of integrated monitoring & early warning system to sustain quality and multifunctionality of surface waters in Cyprus (LIFE TCY 95/CY/B2/CY/868 MED). Interim (1998) and Final (2000) Reports.

Stavri, G. (2005) An economic vision for Cyprus: the Greek Cypriot experience. Turkish Policy Quarterly 4(4).

Thirgood, J.V. (1981) Man and the Mediterranean Forest. A History of Resource Depletion. Academic Press: London, pp. 123–149, ISBN 0-12-687250-3.

Thirgood, J.V. (1987) Cyprus, a Chronicle of its Forests, Land, and People. University of British Columbia Press: Vancouver, UK, 371 p. ISBN 0-7748-0268-5.

UN (2002) Johannesburg Summit 2002. Cyprus Country Profile. United Nations, 58 p.

USAID (2001) The Economic Future of Cyprus: Post-settlement Prospects. United States Aid Agency, 16 p.

Water Development Department, Ministry Of Agriculture, Natural Resources and Environment, Cyprus (2004) Water framework directive. Final Report to EU, Database ENVIS.

WDD-FAO (2002) Re-assessment of the water resources and demand of the island of Cyprus. Synthesis Report. Water Development Department, Ministry of Agriculture, Natural Resources and Environment of Cyprus – Food and Agriculture Organization, Project TCP/CYP/8921, TCP/CYP/2801, Nicosia, Cyprus, 23 + xiv p.

WL Delft hydraulics, ENVECO SA, D. Argyropoulos & Associates (2004) Implementation of Articles 5 & 6 of the Water Framework Directive 2000/60/EC specialised consultancy services under contract No. 39/03/61 for: the MANRE Water Development department of Cyprus Reference conditions, November 2004.

WWF and IUCN (1988) Biodiversity. The Key Role of Plants. Plant Conservation Office: Richmond, UK.

Zohary, M. (1973) Geobotanical Foundations of the Middle East. Vols. 1, 2. Gustav Fischer Verlag: Stuttgart.

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Color Plates

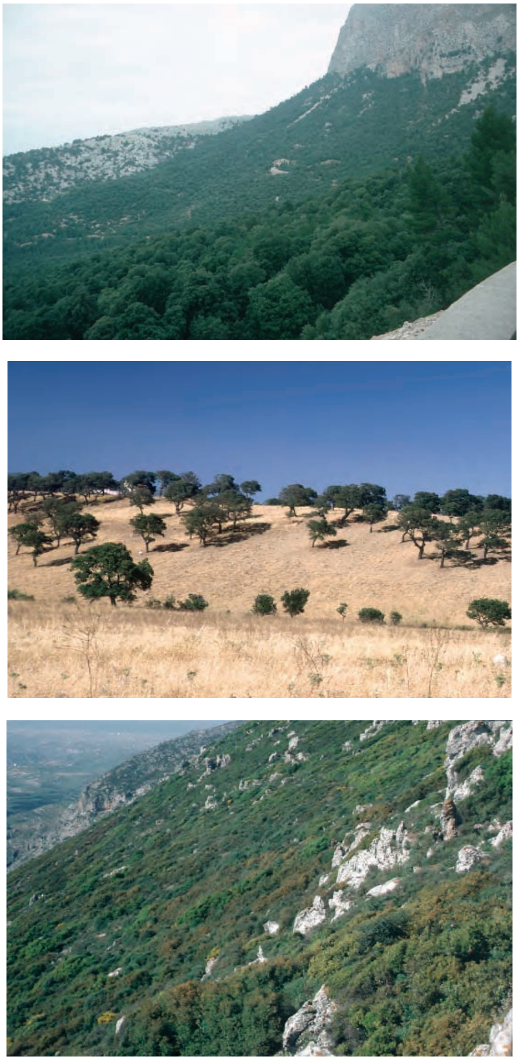

Fig. 3.1 Categories of Mediterranean vegetation (a) Forest of evergreen oak (*Quercus ilex*). Puig Mayor, Mallorca, November 1994 (Photo courtesy of O. Rackham) (b) Savanna of *Quercus ilex* trees, whose spreading shape proves that they are not the remains of a forest. Burgos, Sardinia, July 1995 (Photo courtesy of O. Rackham) (c) Maquis of dwarfed prickly oak (*Quercus coccifera*). Mount Yùktas, Create, May 1988 (Photo courtesy of O. Rackham)

(continued)

Fig. 3.1 (continued) (d) Phrygana of many species of undershrub. Kapsáli, Kythera, May 2001 (e) Steppe of many species of herbaceous plant, stimulated to grow by the burning of the associated phrygana. Kalokairinés, Kythera, May 2001 (Photo courtesy of O. Rackham)

Fig. 3.2 (a) Ancient coppice stool of *Quercus coccifera*, which has been felled and has sprouted many times. Lákkoi, west Crete, July 2005 (Photo courtesy of O. Rackham)

(continued)

Fig. 3.2 (continued) (b) Ancient pollard deciduous oaks (Quercus pubescens). Fonni, Barbagia Ollolai, Sardinia, April 1992 (Photo courtesy of O. Rackham)

Fig. 3.3 Lémnos, most arid of the middle-sized Greek islands. September 2004 (Photo courtesy of O. Rackham)

Fig. 3.11 Archaeology of tourism: decayed spa on the island of Rhodes, dating from the Italian period in the 1930s. Kallithea, March 1990 (Photo courtesy of O. Rackham)

Fig. 5.2 Terraces in Ambelos on the island of Gavdos south-west of Crete (Photo courtesy of G. Kazakis)

Fig. 5.5 The Spinalonga (Kalidon) islet, in the Northeast of Crete in the Elounda bay. The islet is dominated by a Venetian fortress built on the ruins of an ancient acropolis. It has been used from 1903–1957 as one of the last active leper colonies in Europe (Photo courtesy of M. Maragakis)

Fig. 7.2 View of the valley of Sosio (Palermo province), nature reserve and Important Bird Area for various species of birds of prey currently managed by the Agency for State-Owned Forests (Photo courtesy of A. Giordano)

Fig. 7.3 Northern flank of Etna viewed from the Nebrodi Mountains (Photo courtesy of A. Giordano)

Fig. 7.4 View of the Peloritani Mountains SCI and SPA from the Dinnammare summit at 1,152 m; Etna is in the background (Photo courtesy of A. Giordano)

Fig. 7.5 Stands of the endemic *Betula aetnensis* on Etna (Photo courtesy of I. Vogiatzakis)

Fig. 7.7 Typical agricultural landscape of central Sicily (Photo courtesy of A. Giordano)

Fig. 7.9 Sunrise on the Salt Pans of Trapani and Paceco, nature reserve, SCI and SPA, managed by WWF Italy (Photo courtesy of A. Giordano)

Fig. 7.10 Sunrise on the Strait of Messina, a migratory route of international importance (over 320 species of birds recorded till today) an SPA site (Photo courtesy of A. Giordano)

Fig. 7.11 Filicudi and Alicudi islands viewed from the summit of Fossa delle Felci mountain (Salina, Aeolian islands) (Photo courtesy of A. Giordano)

Fig. 8.3 The elongated ridges of the mountains are connected on the highest top of Sardinia: the Gennargentu. The name means Silver Mountain, because snow is visible from the sea till advanced springtime (Photo courtesy of AERONIKE)

Fig. 8.4 The Tortoli pool is one of the coastal lagoons used for fish farming. The origin of this depression is connected with the deep quaternary erosion during the glacial periods. The depression was not completely filled due to the protection of the coastal hills and the absence of important rivers (Photo courtesy of AERONIKE)

Fig. 8.6 This flat valley near the village of Isili (Central Sardinia), is now occupied by the water of an artificial lake, with the old church on a small island. It is easy to identify an elongated hill formed by the hard volcanic rocks that preserved the more erodible calcareous rocks, with an evident example of relief inversion (Photo courtesy of AERONIKE)

Fig. 8.9 The countryside of Nuragus is cut on the Miocenic arenaceous limestones. Orchards and vineyards are filling the valleys in small fields normally cultivated by a single farmer; the top of the flat hills are used for dry pasture (Photo courtesy of AERONIKE)

Fig. 8.10 Agro-silvo-pastoral landscapes in North Sardinia dominated by cork oak (Photo courtesy of I. Vogiatzakis)

Fig. 9.3 Mamonia formation south-west Cyprus (Photo courtesy of Ch. S. Christodoulou)

Fig. 9.4 Pastures and eroded slopes in Pafos (Photo courtesy of Ch. S. Christodoulou)

Fig. 9.6 Mesaoria: Fields, olive groves and patches of natural vegetation (Photo courtesy of P. Delipetrou)

Fig. 9.10 Riparian forest with *Alnus orientalis* in the dry hilly areas of south-west Cyprus (Photo courtesy of Ch. S. Christodoulou)

Fig. 9.12 *Quercus infectoria* stands at the borders of vineyards and fields at Vouni Panagias (Photo courtesy of M. Andreou)

Fig. 9.13 Regeneration of *Quercus infectoria* and other trees-shrubs at abandoned fields with low intension grazing at Lapithiou (Photo courtesy of M. Andreou)

Fig. 9.14 Shrub with *Quercus coccifera-Pistacia terebinthus* and young *Quercus infectoria* at rocky slopes at Vouni Panagias (Photo courtesy of M. Andreou)

Fig. 9.16 View of carob (foreground) and olive (orthogonal planting) trees in the Kyrenia Range that reflect the versatility of layout and response to climate and landform (Photo courtesy of J. Makhzoumi)

Fig. 10.5 Landscapes of Corsica. (Photos courtesy of G. Paradis) (A) Mountainous and Alpine landscapes at Monte Renoso, (B) higher meso-mediterranean landscape at Riventosa, its village, abandoned terraces and typical *Quercus ilex*, *Cistus spp., Erica arborea* and *Arbutus unedo* 'maquis' shrubland, (C) littoral landscape with sand dunes at the Ostriconi river and (D) rocky cliffs at Girolata (Scandola Reserve)

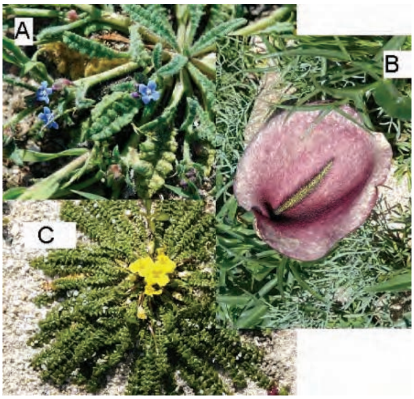

Fig. 10.6 Endemic plants in Corsica (Photo courtesy of G. Paradis) (A) *Anchusa crispa*, (B) *Helicodiceros muscivorus*, (C) *Morisia monanthos*

Fig. 10.7 Emblematic endemic animals of Corsica (Photo courtesy of DIREN Corse) (A) *Gypaetus barbutus*, (B) *Cervus elaphus corsicanus*, (C) *Salamandra corsica*

Fig. 11.3 Dolines as seen from the highest peak Pachnes (2,453 m) of Lefka Ori looking towards the Libyan Sea (Photo courtesy of I. Vogiatzakis)

Fig. 11.4 The Omalos polje at 1,050 in Lefka Ori massif Crete (seen by the Koukoule Mt 1,632) (Photo courtesy of I. Vogiatzakis)

Fig. 11.5 The High Desert on top of the Lefka Ori (White Mountains), a locality very rich in endemic plants. July 1987 (Photo courtesy of O. Rackham)

Fig. 11.6 The last relic of the Miocene rainforest, on the north side of Mount Kryonerítis. April 1988 (Photo courtesy of O. Rackham)

Fig. 11.9 Destruction of maquis on metamorphic rocks in west Crete, the object being to add to the already excessive production of olive oil. Vatólakkos, west Crete, May 1992 (Photo courtesy of O. Rackham)

Fig. 12.4 Minorcan pastures: reminders of English domination in the 18th century

Fig. 12.5 Terraces on the Tramuntana Mountain Range

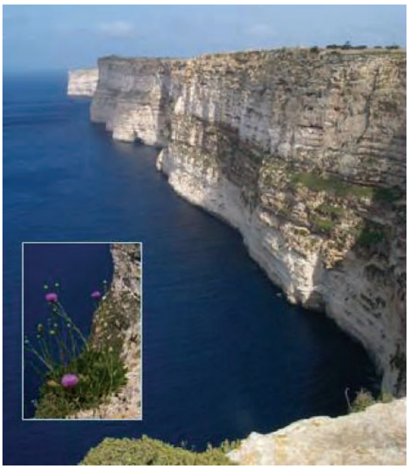

Fig. 13.3 Sheer sea cliffs at Ta' Cenc. Inset shows the endemic *Palaeocyanus crassifolius* (Photo courtesy of L. Cassar)

Fig. 13.4 The Qarraba promontory at Ghajn Tuffieha, consisting of a remnant plateau of Upper Coralline Limestone with surrounding clay taluses and boulder screes (*rdum*) (Photo courtesy of L. Cassar)

Fig. 13.5 Ramla l-Hamra coastal dunes with surrounding agricultural terraces. The site also harbours several archaeological and historical artefacts (Photo courtesy of L. Cassar)

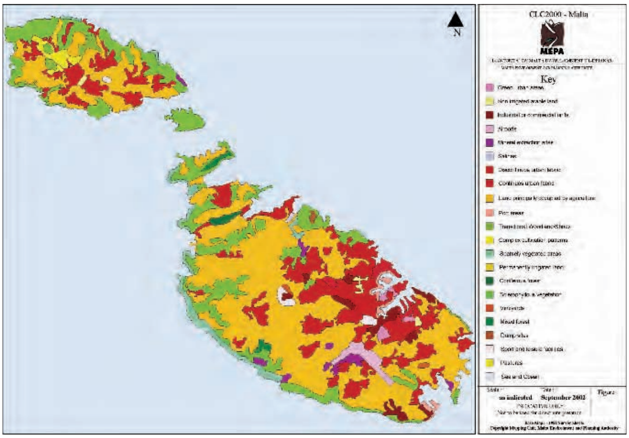

Fig. 13.8 Landcover map of Malta (Reproduced with Permission from Malta Environment and Planning Authority)

Chapter 10
Corsica

F. Mouillot[1], G. Paradis[2], M.-C. Andrei-Ruiz[3], and A. Quilichini[4]

Landscapes of Corsica (Photos by G. Paradis)

[1] IRD-UR060, CEFE/CNRS, France

[2] Office de l'Environnement de la Corse, France

[3] Association Scientifique de Travaux, Études et Recherches sur l'Environnement, France

[4] Laboratoire Evolution et Diversité Biologique, Université Paul Sabatier, France

I.N. Vogiatzakis et al. (eds.), *Mediterranean Island Landscapes.*

10.1 Introduction

Corsica is the fourth largest Mediterranean Island; it is c.183 km north–south, and 83 km east–west and covers 8,682 km^2. It is situated in the western part of the Mediterranean Sea (6°12–7°13 East, 41°9–43° North), at about 90 km west of continental Italy, 14 km north of Sardinia, and 170 km south-east of continental France, its metropolitan attachment. While being part of an initial geological structure which included southern France and Sardinia for millennia, it became isolated at the end of the Miocene era. Corsica is distinct insofar as it is the most northern, the wettest and the most mountainous Mediterranean Island with many peaks over 2,000 m. Most of the island is composed of granite, with a rough cliff and peak topography on its west coast. In its north-east, schists predominate giving a smoother topography (1,767 m maximum at San Pedrone). These two major units are subdivided by a corridor creating not only distinct geological/morphological but also cultural units. Still, today, the north-east part is differentiated from the south-east into two administrative substructures (called 'départements'), namely Haute-Corse (Capital City: Bastia) and Corse-du-Sud (Capital City: Ajaccio) (Fig. 10.1). The former is more agricultural and community based, while the latter is less modified by human activity. A peculiar Quaternary deposition plain covers the east side of the island along the coast and, in the west side, the lower plains of the rivers such as Figarella, Liamone and Gravona are situated (Fig. 10.1).The varied topography gives rise to several different microclimates and vegetation communities depending on altitude, from typical Mediterranean on the coast to alpine above 1,500 m. Summers are usually hot and dry and last from May till October. Winters can be cold and there is generally snow on the highest peaks until June, but by then the ambient temperature on the coast is in the mid-20s °C and the July–September average is 27 °C. The annual average is 12 °C. Annual precipitation varies from 600 mm on the coast to 2,000 mm on the highest peaks and occurs mainly in spring and autumn, with recurrent heavy storm events; up to 400 mm can fall within 24 h, leading to destructive flash-flooding events. Heavy winds can also blow from the north and west (mistral), particularly violent and dry in summer leading to high fire risk. The northern Cape (Cap Corse) and Bonifacio strait in the south experience the fastest winds (up to 150–220 km h^{-1}). The natural vegetation of the island is Mediterranean, comprising forests, woodlands and shrubs, and covers more than half of the island. The coastal lowlands are part of the Tyrrhenian-Adriatic sclerophyllous and mixed forests ecoregion, where forests and woodlands of evergreen sclerophyll oaks predominate, chiefly Holm Oak (*Quercus ilex*) and Cork Oak (*Quercus suber*). The cooler and wetter mountains are home to the Corsican montane broadleaf and mixed forests ecoregion, which support diverse forests of oak, pine, and evergreen deciduous trees, with vegetation more typical of northern Europe on the highest peaks. Much of the coastal lowland and part of the mountain forests have been cleared for human activities.

The population is approximately 272,000 people with about half of them living in the two coastal cities of Ajaccio and Bastia. However, Corte (4,000 inhabitants), situated in the middle of the island at the crossroad of major routes (Fig. 10.1), hosts the Corsican soul, with its university and its historical past as the capital of independent

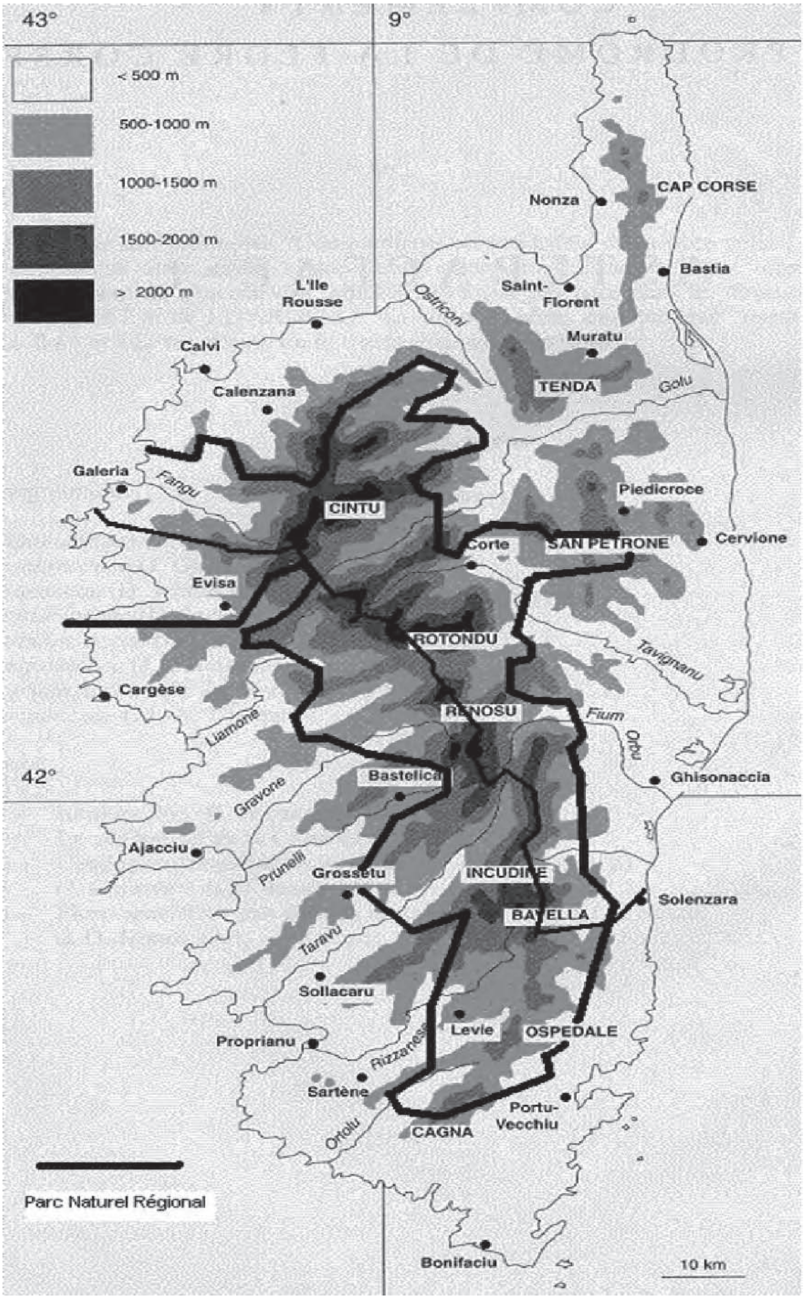

Fig. 10.1 Map of Corsica, Main cities, roads, and limits of the Natural Park (Parc Naturel Regional de Corse)

Corsica. Today the island is an administrative 'region' of France, with a peculiar political status compared to the other metropolitan regions, and an assembly. With 365 villages, many inhabited by less than 100 people, Corsica is the least densely populated 'region' of France, with 30 inhabitants/km^2 vs. 108 in France as a whole while about half the island has a population density of 10 inhabitants/km^2. The earliest signs of habitation, dated to c.6570 BC were of humans living in caves with subsequent development of agro-pastoral practices. Situated at the crossroads of the major maritime trade routes of the Mediterranean 'Old World', invasions from successive civilizations until the 6th/5th century BC, were accompanied by alliances which were just as quickly compromised by the constant arrival of newcomers. After a long and devastating conquest (259–162 BC) the Romans finally seized the island which marked from the 1st century BC a turbulent period in history. This peaceful period (*Pax Romana*) induced relative prosperity in the eastern coastal area. After the collapse of the Roman Empire (5th century) and barbarian invasions, Corsica was finally granted (late 8th century) to the papacy. During that period, indigenous populations had moved to the protected inner mountains in order to avoid the successive coastal invasions. The island was then threatened between 800 and 1100 by the Arabs (the Saracens or Moors – from whom the symbol of Corsica: the Head of a Moor, originated). In 1077, Pope Gregory VII ceded Corsica to Pisa, and in the mid-15th century Genoa administered Corsica harshly and unpopularly, but giving Corsica its Italian flavour. At that time, the now famous Pasquale Paoli headed a rebellion in 1755. He gave Corsica its independence, a capital in the city of Corte, a university and he established the structures of a state in which the 'Corsican nation' is sovereign. However, this period resulted in the cession (1768) of Corsica to France to pay off a debt. One consequence of the transfer was the French citizenship of Napoleon I, who was born in 1769 in Ajaccio, and who is today a figure of the Corsican soul. A short period of English administration, 1794 to 1796 ensued and then administration passed to the French at the Congress of Vienna (1815). French rule brought education and relative order, but economic life remained agrarian. The intervention of French troops and the victorious campaigns of Napoleon strengthened the bonds with France, which, with its colonial Empire, quickly became a land of emigration offsetting a major population increase during the 19th century. Due to its troubled history, a unique climate and topography, and its isolation from continental France, Corsica had to find a compromise between facing the drastic economic changes of the 20th century and, conserving its natural resources which constitute the main wealth of the island.

10.2 Physical Environment

10.2.1 Geology and Soils

Corsica is usually described as a 'mountain in the sea' due to its unique mountainous topography emerging from the Mediterranean Sea. The Corsican Mountains belong to the Alpine orogenic system, distinguished by a complex lithological

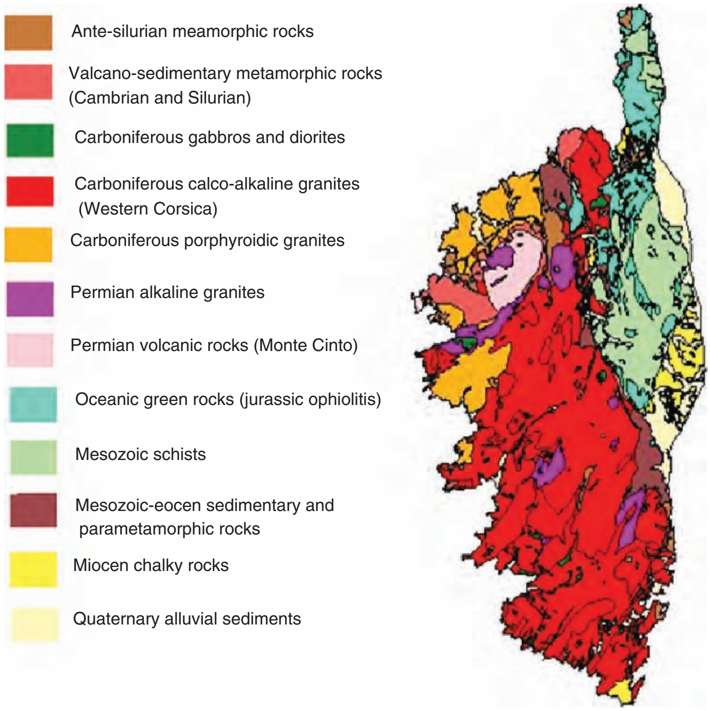

Fig. 10.2 Geological Map of Corsica (From Office de l'Environnement de la Corse)

composition and relief. Crystalline rocks such as granite, rhyolite, gneiss, quartzite, and schist predominate. Glacial reliefs are numerous in the high summits. Mesozoic rocks, mainly limestone, appear occasionally in small and scattered areas. Corsica came into existence about 250 million years ago, when geological uplifts produced the mass of granite which forms the backbone of the island. Some 200 million years later, the uplifts, forced a mass of sedimentary rock against the eastern side of the island. The pressures involved caused a metamorphosis into a folded bed of hard, resistant schists. The later changes to the Corsican landscape were caused by the effects of erosion. Glaciation during the Quaternary had some effect on the highest peaks (Kuhlemann et al. 2005), but most of erosion is the result of the island's abundant precipitation which has given rise to parallel steep sided V-shaped valleys.

The island can be divided into four main geological structures (Fig. 10.2): (1) the initial rocks (west and south) composed of granites with inserts of basic rocks with volcanic zones where the highest peaks stand. The main granite spine of the island takes a meandering north-west/south-east line down the centre of Corsica and covers more than 50% of the island. Monte Cinto is the highest peak at 2,710 m, (2) the schist area (north-east), (3), the corridor in between these two zones, a sedimentary zone from initial rocks and submitted to tectonic and (4) the alluvial eastern plain.

Above this rocky structure, Corsica's soils are typical of the Mediterranean basin, i.e. they are relatively young, poor and superficial with low concentrations of P, N, Ca and K. Due to the steep slopes and runoff which curtails pedogenesis, superficial lithosols have developed on the slopes in contrast with valley bottoms where nutrient-enriched colluvial silts are predominant. Brown soils have developed on acidic rocks under forests, but are rapidly eroded when vegetation is removed (after clearing or fire). Then soils can become red when water alters rocks to liberate ferric oxides, or even bare rocks are exposed on the steepest slopes. Dark brown soils with humus and calcium or clay enrichment are rare, mainly developing in dry areas, under maquis shrublands. On the most arid sites, old Mediterranean red soils occur. These result from the transport of clay and silts; they are poor in organic elements. Alluvial soils characterize valley bottoms and the eastern plain, and are often deep and poor in colloids but rich in minerals.

10.2.2 Climate

Due to its topography, Corsica experiences a wide range of climates (Ascensio 1983). The north-western coastal range (Balagna and Agriate desert) and extreme south can receive less than 600 mm year^{-1} precipitation. At the other extreme, the inner mountains can receive more than 1,500 mm, leaving the protected valley bottoms at intermediate levels of 800/1,000 mm year^{-1} (Fig. 10.3). July is the driest month. As in a typical Mediterranean climate, heavy rainfall events occur regularly. Stormy days average up to 37 days year^{-1} in Ajaccio. Snow is rare on the coast, sparse falls occur mainly in February, but above 700 m, snow is common between October and April and can reach 1 m depth, but does not persist. Above 1,400/1,700 m, snow persists throughout the winter until May providing limited skiing facilities, e.g. at the Vergio pass.

Mean annual temperature is around 15 °C on the coast with a decrease according to altitude of –0.65 °C per 100 m. Above 1,400 m, mean annual temperature is 7°, −1.5 °C at the Mt Cinto. Mean temperatures on the coast in January are 8.5 °C and 23 °C in July and August. The maximum recorded temperature is 41.8 °C (July 25, 1965) and the minimum −15.8 °C (March 1963). Maximum number of days with temperatures under –5 °C are 1–5, and maximum days above 30 °C are 15–40 depending on the location. The west coast is generally sunnier than the east coast. This climatic variation has contributed to a regionalization of cultures and land use.

Fig. 10.3 Yearly precipitation in Corsica (1950–1983). (From Ascencio 1983)

10.3 The Biotic Elements

10.3.1 Vegetation

The altitudinal range of this island gives rise to several forest zones (Gamisans 1978; Figs. 10.4 and 10.5). The driest sites on the coast characterize the thermo-Mediterranean stage. Then, the lowest elevations characterize the meso-mediterranean and supra-mediterranean stages, with the predominance of sclerophyllous evergreen oak forests (*Quercus ilex, Q. suber*). In the medium elevations (400–1,000 m) mesophyllous pine forests (*Pinus pinaster*) are widespread, and mixed deciduous forests (*Quercus pubescens, Q. petraea, Ostrya carpinifolia, Alnus cordata,*

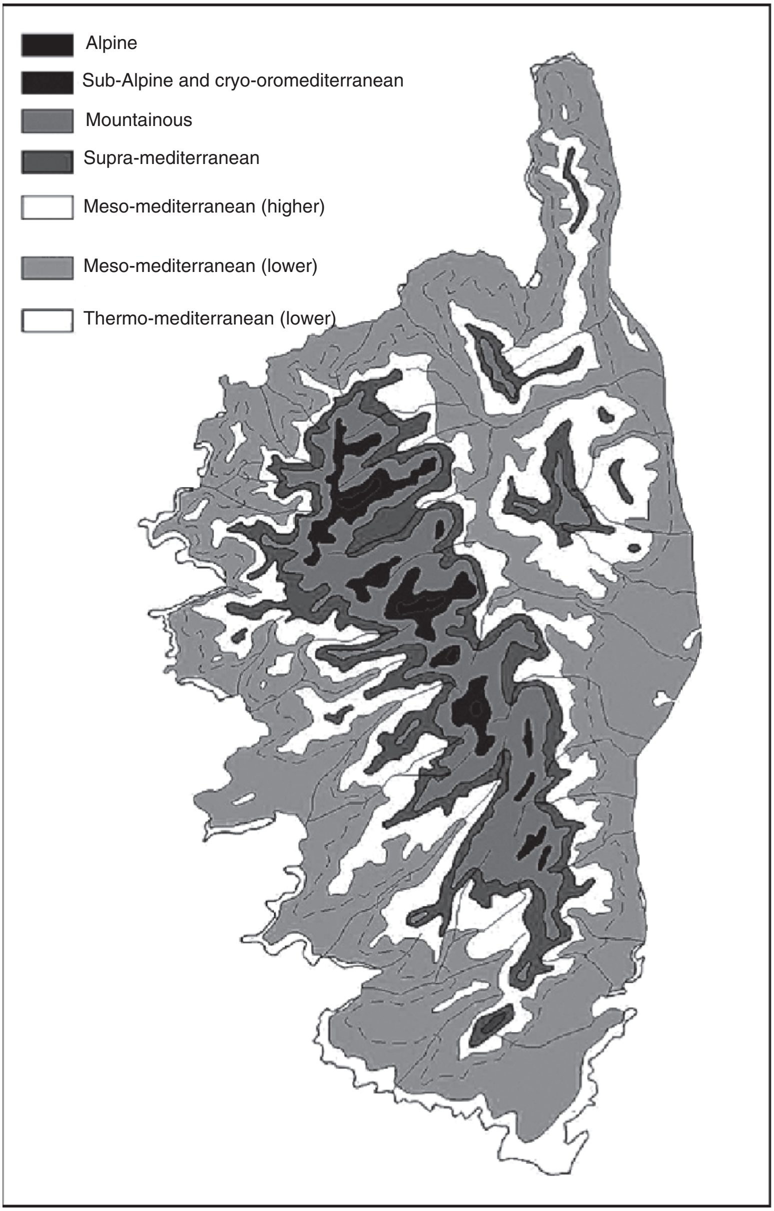

Fig. 10.4 Vegetation zones in Corsica (Paradis 2004)

Castanea sativa) are locally abundant, as in the north-eastern Castagniccia Mountains. A sharp north–south gradient in terms of plant communities typifies the highest elevations of the mountainous stage. *Pinus laricio* dominates on south-facing slopes with a more Mediterranean cold and humid bioclimate, while silver

Fig. 10.5 Landscapes of Corsica. (Photos courtesy of G. Paradis) (A) Mountainous and Alpine landscapes at Monte Renoso, (B) higher meso-mediterranean landscape at Riventosa, its village, abandoned terraces and typical *Quercus ilex*, *Cistus spp., Erica arborea* and *Arbutus unedo* 'maquis' shrubland, (C) littoral landscape with sand dunes at the Ostriconi river and (D) rocky cliffs at Girolata (Scandola Reserve) (*See Colour Plates*)

fir (*Abies alba*) and beech (*Fagus sylvatica*) predominate in the 'mountainous' bioclimate of the north-facing slopes. The high summits are characterized by the subalpine and alpine stages, with the dominance of a dwarf shrub alder (*Alnus suaveolens*), juniper (*Juniperus communis* subsp. *alpina*), and maple (*Acer pseudoplatanus*). Significant relict tree species appear locally all along the altitudinal gradient of the ecoregion, for example the deciduous common oak (*Quercus robur*) occurs in coastal flood-plains, *Juniperus thurifera* woodlands occur in rocky canyons of the continental mountain massifs, and birch (*Betula pendula*) stands occur in the highest elevations. Besides these communities, Corsica hosts various endemic plant and animal species.

10.3.2 Flora

Corsica's flora is a combination of species from North Africa, South West France and the Alps, and includes many endemics such as the alder *Alnus alnobetula* subsp. *suaveolens* and the Corsican pine (*Pinus nigra* subsp. *laricio*). However, this endemic flora is not homogeneous. First, the richness of endemic species depends on the vegetation belt: the higher the altitude, the higher is the relative number of endemic species. Second, as observed in other parts of the Mediterranean Basin, the spatial distribution of endemics is disjoint: though species endemic to the island itself are the most abundant, Corsica shares several endemics with other islands or fragments of adjacent continents. Finally, endemic species can be relicts or newly formed, thus are classified to different categories (Table 10.1). The origins of this flora can be explained by geological events, a unique climate, and intense human activities. This endemic flora is the reason why Corsica is considered a biodiversity hot spot in the Western Mediterranean region (Médail and Quézel 1997).

A taxon is 'endemic if confined to a particular area through historical, ecological or physiological reasons' (Major 1988). Gamisans and Jeanmonod (1993) recorded 2,978 taxa (species range or below) on Corsica. The authors recorded 454 introduced taxa and 2,524 natural taxa, with 2,092 species, 264 subspecies, 89 varieties and 82 hybrids. This endemism represents 12.2% of the flora, i.e. 296 taxa. The endemic species distribution on the island is not homogeneous. While 39.5% belong to the Mediterranean floristic element, the holarctic non-Mediterranean floristic element (Eurasiatic, Eurosiberian, Atlantic, Circumboreal, Arcticoalpine) reaches 37.8% of the flora and dominates the mountain flora, rich in endemic taxa (35.69%). Thus many endemic taxa are found in the island's mountains (154 taxa) where the overall flora is poor. This relatively high richness compared with the total number of present taxa in the alpine range (43.97%) can be explained by reduced competition, allowing endemic species like *Stachys corsica*, *Robertia taraxacoides, Cerastium soleirolii*, and *Galium corsicum* to survive in a wider ecological amplitude than elsewhere (Gamisans 1991). Most of the endemic mountain taxa have affinities to alpine-arctic species, which probably date to periods of climate change in the late Tertiary (Contandriopoulos 1962). These affinities can probably explain the reason why the majority of endemic taxa limited to Corsica are of non-Mediterranean origins.

The percentage of all endemic taxa which occur in Corsica is a function of their endemic distribution (Gamisans and Marzocchi 1996). The authors note that most of the endemic taxa are strictly confined on Corsica (131 endemics, 5% of the flora), but 75 taxa are endemic to both Corsica and Sardinia, a number which might have been higher if Sardinia had higher mountains; 14 taxa are endemic to Corsica, Sardinia and the Tuscan archipelago, 11 are balearic-cyrno-sardinian endemics, and 65 other taxa shared with adjacent territories, other islands or fragments of continent which have historical land connections with Corsica (Table 10.1).

This disjoint endemism involves almost 30% of endemic taxa distributed on the different parts of the cyrno-sardinian tectonic microplate (which fragmented and derivated in the Miocene), but some overseas areas as well. Thus, as suggested by Thompson (2005), 'there is a clear concordance between endemic distribution patterns and the geological history of the region. Corsica integrates the Tyrrhenian flora domain and particularly the Cyrno-Sardinian subdomain, with a consistent Corsican sector, constituting ubiquitous endemic taxa, at all altitudes (Gamisans 1991).

Table 10.1 Example of species endemic to Corsica and other Mediterranean regions. Examples of palaeo-, patro-, apo- and schizo-endemics are also given

	Alps	Pyrenees	Sierra nevada (Spain)	Sardinia (Italy)	Elba (Italy)	Hyeres islands (France)	Calabria (Italy)	Sicily (Italy)	Mallorca (Spain)
Bupleurum stellatum	■								
Viola argenteria	■								
Galium cometherizon		■							
Bunium alpinum subsp. corydalinum			■						
Herniaria latifolia subsp. Litardierei				■					
Limonium strictissimum				■					
Linaria flava subsp. Sardoa				■					
Silene velutina				■					
Nananthea perpusilla				■					
Anchusa crispa				■					
Ptilostemon casabonae				■	■	■			
Alnus cordata							■		
Berberis aetnensis							■	■	
Pinus nigra subsp. laricio							■	■	
Plantago coronopus subsp. humilis								■	
Helicodiceros muscivorus				■					■

Table 10.1 (continued)

		Alps	Pyrenees	Sierra nevada (Spain)	Sardinia (Italy)	Elba (Italy)	Hyeres islands (France)	Calabria (Italy)	Sicily (Italy)	Mallorca (Spain)
Palaeo	*Morisia monanthos*				■					
	Soleirola soleirolii				■					■
	Nananthea perpusilla				■					
	Castroviejoa frigida				■					
Patro	*Pinguicula corsica*									
	Arrhenatherum elatius subsp. sardoum				■					
	Phalaris arundinacea subsp. rotgesii									
	Leucanthemopsis alpina subsp. tomentosa									
Schizo	*Cerastium soleirolii*									
	Cymbalaria hepaticifolia									
	Viola Corsica									
	Genista Corsica									
Apo	*Phyteuma serratum*									
	Draba loiseleurii									
	Alnus alnobetula subsp. suaveolens									

Endemic plants can be relicts, the so-called palaeo-endemic taxa or newly formed, the neo-endemic taxa (Favarger and Contandriopoulos 1961, Stebbins and Major 1965). Karyotype variations based on chromosomal counts specify the affinities between endemic taxa and close corresponding taxa to produce a fourfold classification of endemics: the palaeo-, the patro-, the apo- and the schizo-endemics (Favarger and Contandriopoulos 1961; Table 10.1). The palaeo-endemics are systematically isolated taxa. They are clearly ancient with little variability. The patro-endemics are diploid endemic taxa, representing ancestors of now more widespread and more recent polyploid corresponding taxa. The apo-endemics are polyploid on Corsica (so recent) and possess large area diploid correspondent taxa, out of Corsica. Apo-endemics are thus the reverse of patro-endemics. Finally, both of the schizo-endemics possess one or more corresponding taxa (vicariants) in other areas. They have the same chromosomal number. This category of endemics has undergone a slow-acting differentiation due to the fragmentation of the range of a widespread ancestral taxon. This progressive differentiation has produced endemic taxa in different parts of the original distribution. Contandriopoulos (1962) and Gamisans (1991) proposed that, as patro- and palaeo-endemics underline the conservative character of a flora, schizo-endemics permit to precise to past relationships between Corsica and other territories. They consitute the most important group of endemics, found in the Centre and South European orophilous Mediterranean element. The apo-endemics show that taxa have evolved on Corsica, though they show little variation in other areas.

This endemic richness, coupled with a large number of threatened areas on the island, make Corsica a hot spot of biodiversity (Fig. 10.6). On a total of 173 protected species at different levels (regional to international), 52 species are endemic (almost 30%).

10.3.3 Fauna

Despite a high level of plant biodiversity in Corsica, the number of animal species on the island is significantly lower than continental France, particularly for the well-studied group of mammals. Today, there are 17 mammal species on the island (excluding chiroptera); most derive from continental Europe, and many reflect deliberate and accidental introductions, e.g. the rat (*Rattus rattus frugivorus*). Hunting practices have also reduced the population of some species and eradicated others.

Once dominant, this group of endemics has largely disappeared. These include squirrels, ermines, shrew (*Episoriculus corsicanus*), Sardinian Pika (*Prolagus sardus*), mole (*Talpa tyrrhenica*) and otter (*Algarolutra majori*). Only a rare and endemic herbivore, the emblematic Corsican moufflon (*Ovis gmelini musimon var. corsicana*), is still naturally present in the region's forests. The population of the endemic deer species (*Cervus elaphus corsicanus*, Fig. 10.7), an endangered species included in the IUCN Red List of threatened fauna, is the result of a successful reintroduction from Sardinia. This is the only area where this species still survives in the wild nowadays. Flying mammals such as chiroptera, are well represented

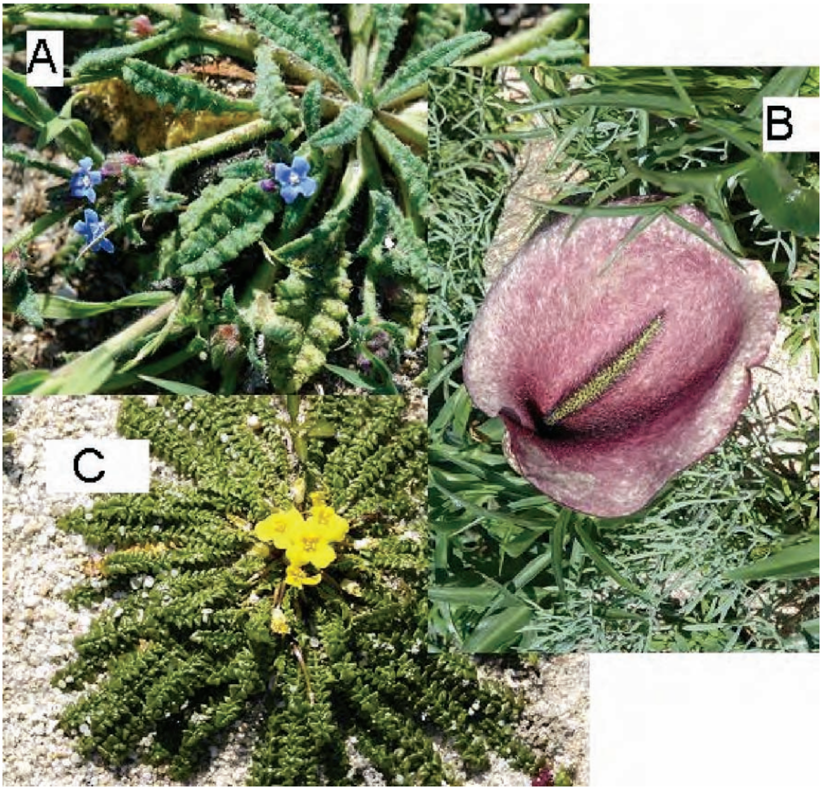

Fig. 10.6 Endemic plants in Corsica (Photo courtesy of G. Paradis) (A) *Anchusa crispa*, (B) *Helicodiceros muscivorus*, (C) *Morisia monanthos* (*See Colour Plates*)

with 26 species, but there are no endemic species. There are also very few bird species on the island; notably 109 nesting species, 152 visiting species and 3 introduced species. The forests of the Corsican Mountains also host a number of birds. These include the endemic Corsican nuthatch (*Sitta whiteheadi*), which is ecologically adapted and restricted to mature pine trees of the *Pinus laricio* old-growth forests, two species of endangered raptors and rare Palearctic birds such as the bearded vulture (*Gypaetus barbatus*, Fig. 10.7). Some endemics have disappeared as for example, the eagle owl *Bubo insularis.*

Corsica hosts also only 7 amphibian species and 12 reptiles (2 turtles, 4 lizards, 3 snakes, and 3 tarantulas), but with many endemic species as *Euproctus montanus, Discoglossus montalentii*, and a salamander (*Salamandra corsica*, Fig. 10.7*)*, or Bedriaga lizard (*Lacerta bedriagae*). Some species are not represented as web-toed salamander (*Hydromantes spp.*) present on the neighbouring island of Sardinia, tritons, and vipers. Among the reptiles, the most representative species of this ecoregion are also typical of similar forest ecosystems such as

Fig. 10.7 Emblematic endemic animals of Corsica (Photo courtesy of DIREN Corse) (A) *Gypaetus barbutus*, (B) *Cervus elaphus corsicanus*, (C) *Salamandra corsica* (*See Colour Plates*)

mountain conifer and broadleaf mixed forests from the southern European Mediterranean countries. Examples are *Algyroïdes fitzingeri, Podarcis tiliguerta* and *Podarcis sicula*. Although the terrestrial molluscs community is relatively poor, recent studies illustrate a diverse community, with a high level of endemism. Among the 160 taxa, 25% are strictly endemic to Corsica but sporadically represented, e.g. Corsican Snail *Tyrrhenaria (Helix) ceratina*; 500 species of spiders are present on the island with 80 endemics. Among them, the Corsican Mygale (*Cteniza sauvagesi*) is distributed only in Corsica, Sardinia and the Pontines islands.

Finally, insects are sparsely represented even given the fact that not all species have been documented. For lepidoptera, it is generally assumed that continental France hosts 5,111 species (Lerault 1997). In Corsica, there are only 1,384 species (Rungs 1988). Recently some new butterfly species have been discovered but Corsica remains an island with few species. Indeed, famous species as *Parnassius* and *Erebia* have never been observed in Corsica. On the contrary, according to Lerault (1997), 137 species (and 84 subspecies) have only been observed in Corsica (for France), either because they are endemics (*Papilio hospiton, Fabriciana elisa*) or because they are on the border of geographic repartition. Less than 50 species of Dragonflies are observed in Corsica (100 in France), only 4 cicada species (16 in France) among which 3 are endemics as *Cicadetta fangoana*, which was recently registered.

10.4 Cultural Landscapes

Due to its history, Corsica is usually considered more as a mountainous area than an island, and until the 20th century, most of the people lived in the inner valleys for protection from invaders coming from the sea. Indeed, the sea is not the main component of the Corsican soul and culture, neither in relation to food, nor economy; the sea has been considered as a barrier rather than an open door to neighbouring countries. The first regular sea link with continental cities started only in 1960 (Simi 1981).

The Cape Corse region is more open to sea resources, as it is only 40 km wide, and almost every village has an access to the sea. Apart from this peculiar region, Corsican landscapes are fairly homogeneous, with a distinction for the Castagniccia region (876 km^2, north-west Corsica, on the schistic zone). This is strongly influenced by chestnut trees ('Castagna' in Corsican language), and totally modified by humans (Pitte, 1986). There, chestnut trees (called 'Bread fruit tree' in the 19th century) replaced the original oak forest in a context where importations were limited and populations had to survive in the inner mountains (Caratini, 1995). Chestnuts were used for the fruit itself, converted to flour, and used as animal forage with a high nutritive value compared to wheat. Centuries of chestnut cultivation left this region 50–90% covered by chestnut trees. At that time, the forest was managed and understorey vegetation was cleared. Castagniccia was one of the richest and most populated regions until the 19th century, with peculiar habitations built for the storage and transformation of chestnuts. Since the beginning of the 20th century, when trading with continental cities was easier and the wheat market accessible for importation, exploitation of chestnuts collapsed. These forests still remain, but have now been abandoned for decades. The understorey vegetation developed as a dense shrubland of typical Mediterranean vegetation and the oak forest progressively reinvaded its original territory. At the same time, tannin industries promoted deforestation because of their wood requirements (19th century), and fire-prone shrublands progressively developed. The collapsing and aging forest also became progressively infested with fungi like *Phytophthora* on roots and barks, and more recently by *Endothia parasitica* on barks and branches, as well as insect attacks on trees but more particularly on fruits. Nevertheless, Castagniccia still remains a distinctive densely forested landscape of north-eastern Corsica.

Besides these two regions, Corsican landscapes are more the consequence of traditional practices oscillating between a typical Mediterranean climate and an alpine climate influence. As a consequence, most villages are located around 800/1,000 m altitude, at the boundary between the cultivation zone below this altitude and the sylvo-pastoral area above (Fig. 10.5). The cultivation zone is devoted to cereals (wheat, maize), olive trees on the driest parts, and rye or chestnut trees on the wetter higher altitude and north-facing slopes. Extending these cultivations from the valleys to more mountainous areas during the 19th century population growth required the building of stone terraces that covered most of the island according to the land-use/landcover map (called Plan Terrier, Albitreccia (1942) ordered by King Louis 15th when Corsica first belonged to France in 1772. After land abandonment, these constructions were progressively affected by erosion and today their remnants are covered by the invading shrublands. Orchards, private gardens for vegetables and vineyards are only located around villages and still remain nowadays for private use. Chestnut orchards are, however, mostly abandoned. Past cultivation areas are now colonised by shrublands and pine oak forest, mainly used for pastures and recurrently cleared by burning. For centuries, shepherds have been acknowledged to use both private and common territories for their sheep and cattle grazing (Etienne 1977; Joffre 1982). They now remain the only inhabitants of a sparsely populated region where territories are abandoned. The only way to guarantee enough forage is to clear the landscape as soon as unpalatable shrublands have developed. That process takes only around 5–7 years in this wet area of the Mediterranean. The use of fires to clear the landscape is neither a new tool in the Corsican land-management practices, nor a rare disturbance in this type of ecosystem (Cerutti 1990). Actually, Mediterranean vegetation is fairly adapted to recurrent fires with protection organs as thick cork layers (*Quercus suber*), seed resistance (*Cistus spp, Pinus halepensis*), or resprouting abilities (*Quercus ilex, Erica arborea*). However, human practices have shifted from low intensity fires to remove the debris after clearance, to total burning of biomass leading to uncontrolled intense fires (Joffre 1982). Above 1,000 m, landscapes are mostly forested and rocky, and devoted to summer grazing on alpine pastures, around glacier lakes. Old sheep-folds bear witness to past grazing activity in the upper mountains when the lower valleys were too dry in summer. At the highest altitudes there are also emblematic *Pinus laricio* forests which were used in the 18th century by the naval industry for shipbuilding. The forest remains managed but not really for commercial use.

10.5 Recent Environmental Changes

After centuries of a closeted way of life in inner Corsica based on self-sufficiency and protection, coupled with a constant population growth, the 20th century was marked by the collapse of traditional practices and the emergence of modern Corsica. Recent environmental changes have then been driven by changes in population density and distribution, and the consequent changes on human practices and land uses (Box 10.1). The maximum population reached 290,000 inhabitants at the beginning of the 20th century and rapidly collapsed, particularly in the inner mountains, to 190,000 in 1950 (Simi 1981).

10.5.1 Rural Exodus, Land Abandonment

The population collapse particularly occurred in the villages of inner Corsica. The lack of land following population growth, and the ongoing isolation within a world shifting to international trading and communication, lead to heavy emigration at the

Box 10.1 Corsican Landscapes in the 21st Century: The Threat of Global Changes

Corsica, like most of the Mediterranean landscapes, has been submitted to intense land abandonment and substantial changes in climate for the last decades. Recent observations indicate the development of shrublands and forests on previously cultivated areas, in a context where summer-drought and temperatures are increasing. In the future, the impacts of these changes on ecosystems may result from complex interactions between direct effects on vegetation functioning, water stress and subsequent modifications in flammability and fire regime leading to changes in standing biomass and plant species composition. Dynamic and functional vegetation models dealing with fire risk assessment, and coupled with climate scenarios issued from atmospheric models are useful tools to apprehend the complex interactions between processes. Meteorological models predict that climatic changes in Corsica, under double atmospheric CO_2 concentration expected at the end of the 21st century, would cause an increase in temperatures, particularly in summer (+4°C), and a change in the rainfall pattern leading to a decrease in low rainfall events and an increase in intense rainfall events (heavy storm events). Based on this result, and applied to a study case on the typical Maquis shrubland/forest ecosystem of Corsica, Mouillot *et al.* (2002) concluded that there would be no drastic changes in the post-fire succession process, but modifications in the water budget and an increase in the length of the drought period varying between 0 and +8 weeks. Regarding fire frequency, climate changes tend to decrease the time return interval between two successive fires from 20 to 16 years for the shrublands and from 72 to 62 years in the forested stages. This increase in fire frequency leads to shrub dominated landscapes where forests tend to disappear (from 30% to 13% for dense forest in Fig 10.8), which accentuates the yield/loss of water by additional deep drainage and runoff. This is without accounting for changes in human pressure, management policies and the relation of people to fire, that could mitigate this result.

beginning of the 20th century. Targeted destinations were mainly emerging big cities on continental France, but also North America and agricultural French colonies, especially those in North Africa. This process was accentuated by the reduction in the male population during World Wars I and II. Indeed, in the 1950s, the aging population could not maintain agricultural activities, and traditional practices were no longer attractive in a context of new policies adapted to the European or global markets, especially the demand for increased efficiency. Consequently, only arable lands accessible to mechanization were maintained and the degradation of terraces began on the steeper slopes. During that period, cultivated areas declined from 30.3% during the 19th century to 7.4% in 1929 (Simi 1981), and cultivated forests as chestnut forests and olive orchards were abandoned to degradation, and invasion by competitive species. Only a few orchards continue to be maintained around villages. In addition pastures disappeared along with numerous orchid species (for example,

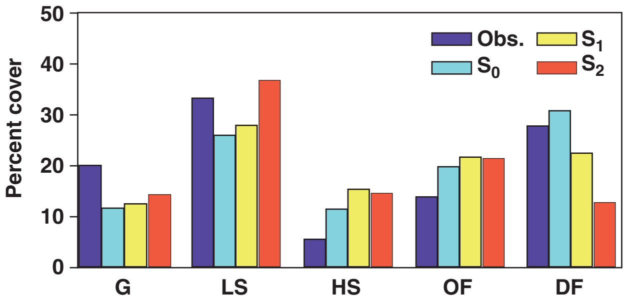

Fig. 10.8 Landscape composition (Grassland (G), Low Shrublands (LS), High Shrublands (HS), Open forests (OF), Dense forest (DF)) for the observed scenario, current climate S0, changes in rainfall (S1) and changes in rainfall + temperature (S2)

Ophrys tenthredinifera) due to the invasion of chamaephytes (*Teucrium capitatum, Teucrium marum* and *Cistus spp.*), which were subsequently succeeded by a dense shrubland with *Quercus ilex, Phillyrea angustifolia* and *Juniperus oxycedrus*.

Since the 1950s, the main activity has been sheep, goat and cattle rearing. This activity was maintained by the blue cheese factory of 'Roquefort Société' (headquarters in southern France), which utilized sheep milk. This kept rural villages alive. However, free grazing in Corsica has been allowed for centuries, but is rarely balanced with forage production. Indeed, in some fragile areas, overgrazing by cattle progressively increased the alteration of montane pastures (the protected high altitude pastures called 'pozzines' around glacial lakes) and coastal dunes. In addition, widespread pig grazing became uncontrolled, and after the 1970s the traditional use of nose rings, preventing pigs from digging and spoiling grasslands, was abandoned. On other (and major) areas, the whole landscape has rapidly been invaded by 'maquis' shrublands and grasslands, closing up the territory with a dense, unpalatable and fire-prone vegetation of *Cistus spp, Arbutus unedo* and *Erica arborea* (Barry and Maniere 1975; Joffre et al. 1982; Mouillot et al. 2005). The low severity traditional burnings used to clean-up debris from deforestation were extended as a landscape clearing tool and applied to a dense and flammable vegetation over large homogeneous areas. Then, fires were set more frequently and could spread more easily. In some places, these frequent fires progressively altered soils and substrates where plants can hardly establish, whereas soil deposits can modify substrates in valley bottoms. Fires in Corsica mainly affect shrublands, so the forest still develops at a rate of 1% year^{-1} (Mouillot et al. 2005), despite this high fire frequency, but could be much higher. The major process involved was the recurrence of fires in previously burnt areas with a fire return interval of 7–12 years while other areas keep being unaffected for decades (Mouillot et al. 2003). As a consequence, forests progressively develop next to shrubland/grassland zones affected by recurrent fires. These shrublands are now generally maintained into their shrubby stage.

10.5.2 Modern Agriculture on the Eastern Plain

The second half of the century was marked by the emergence of coastal cities for tourism and the eastern plain for agriculture. On the eastern plain, composed of coastal lagoons and sandy beaches, no major city developed until recently. The plain remained unused until the 20th century except for the Roman city of Aleria, and has long been infested with mosquitoes carrying malaria. Droughts, hunger and epidemics have deterred colonisation. At the end of the 19th century, treatment for malaria as well as pumping and drainage were developed with success, allowing the population to develop settlements which led to the total exploitation of the plain in the 1950s (Simi 1981). Agricultural development on the eastern plain induced significant environmental changes as, for example, the creation of dams on lower valleys (Peri, Teppe Rosse, Alzitone on the eastern plain), soil drainage, lagoons transformations, the use of pesticides and nutrients inputs. Among other consequences, the filling up of marshes and lagoons (e.g. St. Florent, Porto Novo, Pinarello) by individuals or town councils, caused the disappearance of species in these habitats. Eutrophication due to phosphorus and nitrogen release from fertilizers used in agriculture is also threatening coastal lagoons due to the development of competitive species such as *Ceratophyllum demersum* and *Paspalum distichum.*

This agricultural development unfortunately coincided with the lowest population density of the island after decades of emigration since the beginning of the century. The French decolonization of northern Africa (1962) resulted in the return of hundreds of settlers hitherto employed and experienced in agriculture in a Mediterranean climate, alongside with their northern-African employees. The development of the eastern plain was a success within a few years, leading to the economic development of Corsica's poorest region with a reverse trend in inner Corsica. The separation of the local and migrant communities, due to geographical, historical and cultural differences, and particularly the invasion of settlers in this uninhabited region, inevitably created tensions and misunderstandings, and enhanced the revival of the independence ideology. However, at the end of the 20th century the plain is an arable and productive zone for vineyards and fruit trees with a modern landscape structure and cypress hedges to provide protection from cold winds. Trees orchards cover 3,500 ha in 1977 for citrus fruits and Corsica became the first French producer and exporter. Corsica specialized into seedless tangerines. Other fruits, vegetables (670 ha), olives (229 ha) and chestnuts (157 ha) represent a minor fraction of cultivations. The main land uses are vineyards covering 32,000 ha in 1976. The case of vineyards in Corsica (Simi 1981; Levratto 2004), as a traditional production since antiquity, followed the shift from the small private vineyards covering 9,000 ha in the mountains in 1960, to an industrial production on the eastern plain. However, the low quality of these wines induced the collapse of the production and abandonment of vineyards, covering only 7,000 ha in 2004. Only the traditional sites returned the activity, under quality labels (Appellation d'Origine Controlée, AOC): Cape Corse Muscat, Ajaccio, Patrimonio and Vin de Corse (covering the whole vineyard).

10.5.3 Tourism and Coastal Development

In Corsica, the main threat to landscapes and species conservation is tourism and it is localized in the more sensitive zones: the coast and higher mountains. Tourism is a long standing activity in Corsica with the British and Russian vacation spots in Ajaccio since the 1850s, an activity which exploded in the 1970s with 700,000 tourists a year near Porto-Vecchio, Calvi and Ajaccio and the eastern plain (Bona 2004). Benefiting from its mild climate, various landscapes, nice beaches, and peculiar traditions and culture, Corsica invested most of its activity on tourism. Even if it is far from being comparable with the Balearic Islands (Spain), tourism seriously affects coastal sand dunes. Mountain areas are more protected with fewer tourists and many are actively concerned with species conservation (Richez 1993, 1994). Coastal conservation problems are exacerbated by sand use for construction or for tourism activities and habitations. These as well as road and resort development near the coast, and trails on the dunes threaten these habitats, exacerbate wind erosion, and have modified marine streams and convections and, in turn, affected sand deposition or erosion. In the coastal sand dunes only the endemics *Anchusa crispa* and *Linaria flava* subsp. *sardoa* are legally protected.

10.6 Landscape Conservation

In Corsica, most rare species are on the less suitable sites for vegetation development, e.g. sand dunes and coastal cliffs, marshes and ponds subject to alternate floods and drought, cliffs in the mountains and overgrazed areas. These areas unfortunately appear to be the most exposed to recent changes in human pressure, and many efforts now focus on keeping the long-standing features of Corsican landscapes and diversity. Consequently, efforts have been made to classify protected species according to their distribution area, and to determine conservation priorities. The most protected species are endemics unique to Corsica (e.g. *Thymelaea tartonraira* subsp. *thomasii*), then endemics to both Corsica and Sardinia, and endemics common to Corsica, Sardinia and the Balearics. Legally, a list of protected species was published on May 13, 1982, 6 years after the law on the protection of species (July 10, 1976), and was modified on August 31, 1995; 450 taxa of species or subspecies for France, and 127 in Corsica. At the regional level, an additional list was published (July 24, 1986) with 62 additional taxa, most of which were included on the national list in 1995. In 2005, only 56 taxa belong to the regional list. However, these lists are just indicative and do not invoke any legal procedure or fine in case of species destruction or collection. In France, Plant National Museums (conservatoires botaniques nationaux) aim to conserve existing plants. The 'Conservatoire Botanique National Mediterranéen' in Porquerolles (CBNMP) is in charge of southern France, including Corsica. The institution conserves species ex situ so that reintroductions can be made in cases of destruction. Seeds are collected and stored, as well as vegetative parts such as bulbs, rhizomes or lignotuber. For example, in Corsica, CBNMP has reintroduced the populations for two endemics: *Anchusa crispa* on the site of Portigliolo (in 1992), *Brassica insularis* on the calcareous cliffs at Punta Calcina (north Porto Vecchio) in 1996, and the non-endemic *Armeria pungens* on sand dunes at Sperone (Bonifacio) in 1992. Besides this list of species, numerous local and national agencies were created for the protection and conservation of habitats in Corsica, juxtaposed with maintenance of human populations within these habitats. The French Ministry of Ecology is the main financial support for protection of species and habitats, and, at the regional level, DIREN (Direction Regional de l'Environnement) and OEC (Office de l'Environnement de la Corse). DIREN is the regional representation of the minister in each region of France, while OEC was created in 1993 and is specific to Corsica. Another important environmental organization in Corsica, depending on OEC and DIREN, is the Regional Park PNRC (Parc Naturel Régional de Corse), created in 1972 and covering 350 000 ha. Its main objective is to limit land abandonment and maintain traditional landscapes and human practices. Among others, its main success was to maintain breeding in the inner mountains, encourage the restoration of sheepfolds, and the creation of mountain trails and guest houses, and focus on keeping the three emblematic threatened species Corsican moufflon (*Ovis gmelini musimon*var *corsicana*), bearded vulture (*Gypaetus barbatus*) and osprey (*Pandion haliaetus*). The conservation effort on subalpine pastures 'pozzines' around montane and subalpine lakes as Lac de Creno, Lac de Nino and Renoso with protection and management, allowed, for example, the threatened population of *Drosera rotundifolia* to grow. The Corsican deer (*Cervus elaphus corsicanus*) was also reintroduced from Sardinia, and the natural reserve of Scandola (north-east of the island on the coast) was created. The National Forest Service (ONF) is more focused on protection of species in the forests only and forest management. At a local/regional level, towns or counties created natural reserves (Table 10.2).

Within these reserves, hunting, fishing or diving is forbidden, and management plans are settled to maintain habitat quality and rare species. For instance, in Lavezzi islands, grazing was suppressed to allow for natural vegetation to regrow. At local level, the Conservatoire de l'Espace Littoral et des Rivages Lacustres (CEL, French Minister for Ecology) bought some sites on coastal Corsica (c.15,000 ha, Table 10.2). In this way, numerous small sites have been designated mainly on small rocky capes. Managements of these sites belong to the city councils.

As on continental France, the 'Arrêtés de Biotope' for some specific sites have been created for the protection of rare species which can be animals as Audouin's gull (*Larus audouinii*) or plants (e.g. *Silene velutina* or *Nananthea perpusilla*). Within these sites, it is forbidden to build, and to access during bird nesting periods. Natural Zones of Ecological, Faunistic and Floristic Interest (Z.N.I.E.F.F.) have been created to protect threatened habitats and rare species at the national level. In 2005, the French Minister of Ecology decided for each region to select a scientific council for nature conservation: the CSRPN (Conseil Scientifique Régional du

Table 10.2 Protected areas in Corsica

Reserve name	Reserve type*	Surface area (ha)	Date	Protected species
Finochiarola islands	Nat. Res.	3	1987	*Hibiscus kosteletskya pentacarpos*
Scandola	Nat. Res.	1511	1975	*Armeria soleirolii* *Seseli praecox* *Vitex agnus-castus*
Cerbicales islands	Nat. Res.	36	1981	*Helicodiceros muscivorus*
Bonifacio strait	Nat. Res.	79460	1999	*Nananthea perpusilla* *Ipomoea sagittata* *Armeria pungens* *Silene velutina* *Helicodiceros muscivorus* *Spergularia macrorhiza* *Evax rotundata* *Asplenium marinum* *Mesembryanthemum crystallinum*
Tre Padule de Suartone (Paradis and Pozzo di Borgo, 2005)	Nat. Res.	217	2000	*Isoetes velata* *Isoetes hystrix* *Pilularia minuta* *Drimia (Urginea) maritima* *Drimia (Urginea) undata* *Littorella uniflora* *Ranunculus ophioglossifolius* *Ranunculus revelierei* *Ambrosina bassii* *Gennaria diphylla* *Orchis longicornu* *Serapias nurrica*
Agriates	CEL	6000		
Valinco bay	CEL	2094		
Bonifacio	CEL	2132		
Piana islet (Ajaccio)	AB			
Porto-Vechio islets:				
Ziglione, Stagnolu, Cornuta, Roscana				
Capense islet (Cap Corse)				
Erbaju sand dunes (Ortolu river)				
Northern Cape Corse,	ZNIEFF			
Albo				
Nonza,				

(continued)

Table 10.2 (continued)

Reserve name	Reserve type*	Surface area (ha)	Date	Protected species
Ostriconi delta				
gulf of Porto				
Sanguinaires islands				
gulf of Valincu				
Roccapina hills				
Restonica valley				
pass of Bavella				

*Nat. Res: Natural reserves, CEL: Conservatoire de l'Espace Littoral, AB: Arrêté de Biotope, ZNIEFF: Natural Zones of Ecological, Faunistic and Floristic interest.

Patrimoine Naturel), composed of plant and animal specialists. They compiled a list of remarkable taxa to justify for ZNIEFF and to determine their contour line and area. Some sites, classified for their remarkable landscapes (from the 1930 law) can facilitate the conservation of some species.

More recently, the Natura 2000 network aims to protect biodiversity in the European Union. Its goal is to maintain or restore natural habitats of great floristic and faunistic importance. Creating these zones must contribute to fulfilling the objectives from the Rio conference on biodiversity in 1992. The network will host sites named by each European country for birds or habitats. Some sites were proposed in Corsica, but it is not yet decided which one will be designated. In France, the application of this network faces misunderstanding and conflicts with unions of hunters, even though hunting will be allowed within these sites, together with agricultural and breeding activities.

References

Albitreccia, A. (1942) Le plan terrier de la Corse, Presses Universitaires de France: Paris.

Ascensio, E. (1983) Aspects climatologiques de la région Corse. Ministère des transports, direction de la météorologie, Boulogne Billancourt, France, 19 p.

Barry, J.P. and Maniere, R. (1975) Histoire et végétation d'une commune rurale de la vallée du Tavignano, Poggio di Venaco, de 1843 à nos jours. Université de Nice, UER domaine méditerranéen: Nice, France.

Bona, J.-M. (2004) Le tourisme en Corse. Encyclopaedia Corsicae, Vol. 6, Éds Dumane. Bastia, France, pp. 547–554

Caratini, R. (1995) Histoire du peuple Corse. Criterion Eds. Paris,345 p.

Cerutti, F. (1990) La Corse, île de feu. Rev. Forestière Française, 42: 46–56.

Contandriopoulos, J. (1962) Recherches sur la flore endémique de la Corse et sur ses origines, Annales Fac. Sci. Marseille, t. XXXII, 354 p.

Etienne, M. (1977) Un essai d'amélioration des ressources pastorales en Corse. Fourrages 71: 83–92.

Favarger, C. and Contandriopoulos, J. (1961) Essai sur l'endémisme. Bulletin de la Société Botanique Suisse 77: 383–408.

Gamisans, J. (1978) La végétation des montagnes Corses. Phytocoenologia 4 377–442.

Gamisans, J. (1991) La végétation de la Corse. Compléments au Prodrome de la flore corse, Annexe n° 2. Editions des Conservatoire et Jardin botaniques de la Ville de Genève, 391 pp.

Gamisans, J. and Jeanmonod, D. (1993) Catalogue des plantes vasculaires de la Corse, 2nd edn., in Compléments au Prodrome de la flore corse. Annexe n° 3. Editions des Conservatoire et Jardin botaniques de la Ville de Genève, 258 pp.

Gamisans, J. and Marzocchi, J.-F. (1996) La flore endémique de Corse. Edisud. Aix-en-Provence, France.

Joffre, L.M., Joffre, R. and Casanova, J.B. (1982) Evolution de l'utilisation pastorale du territoire de la commune de Poggio di Venaco de 1920 à 1980. Report, 'Parc Naturel Régional de Corse': Ajaccio, France.

Joffre, R. (1982) Réflexions sur le feu pastoral en Corse. Premiers résultats de l'étude comparative des parcours incendiés et des parcours améliorés dans le centre de la Corse. Fourrages 91 73–98.

Kuhlemann, J. Frisch, W. Székely, B. Dunkl, I., Danišík, M. and Krumrei, I. (2005) Würmian maximum glaciation in Corsica. Austrian Journal of Earth Sciences 97: 68–81.

Lerault, P. (1997) Liste systématique et synonymique des Lépidoptères de France, Belgique et Corse (deuxième édition). Supplément à Alexanor, 526 p.

Levratto, N. (2004) Une agriculture déstructurée. In vol. VI (Droit, Economie, Politique): 507–510. Encyclopaedia corsicae, éditions Dumane, Bastia, France.

Major, J. (1988) Endemism: a botanical perspective. In A.A. Myers and P.S. Giller (eds.) Analytical Biogeography. An Integrative Approach to the Study of Animal and Plant Distributions. Chapman & Hall: London, pp. 117–146.

Médail, F. and Quézel, P. (1997) Hot-spots analysis for conservation of plant biodiversity in the Mediterranean Basin. Annals of Missouri Botanical Garden 84: 112–127.

Mouillot, F., Rambal, S. and Joffre, R. (2002) Simulating climate change impacts on fire frequency and vegetation dynamics in a Mediterranean-type ecosystem. Global Change Biology 8(5): 423–437.

Mouillot, F., Ratte, J.P., Joffre, R., Moreno, J.M., and Rambal, S. (2003) Some determinants of the spatio-temporal fire cycle in a mediterranean landscape (Corsica, France). Landscape Ecology 18: 665–674.

Mouillot, F., Ratte, J.-P., Joffre, R., Mouillot, D. and Rambal, S. (2005) Long term forest dynamic after land abandonment in a fire prone Mediterranean landscape (Corsica, France). Landscape Ecology 20: 101–112.

Paradis, G. (2004) Carte des étages de végétation de la Corse. Bull. Soc. Bot. Centre-Ouest, 35: 456.

Paradis, G. and Pozzo Di Borgo, M.-L. (2005) Étude phytosociologique et inventaire floristique de la réserve naturelle des Tre Padule de Suartone (Corse). Journal de Botanique de la Société botanique de France 30: 27–96.

Pitte, J.R. (1986) Terres de Castanides. Fayard: Paris.

Richez, G. (1993) Le grand site de la vallée de la Restonica: fréquentation touristique 1989–1992 et premières réflexions sur la capacités d'accueil. Trav. sci. Parc nat. région. Corse et rés. nat. de Corse 44: 1–55.

Richez, G. (1994) Aspect de la fréquentation touristique et récréative de la vallée du fangu durant l'été 1992. Trav. sci. Parc nat. région. Corse et rés. nat. de Corse 45: 1–82.

Rungs, C.E.E. (1988) Liste inventaire systématique et synonymique des Lépidoptères de Corse. Supplément au tome 15 d'Alexanor, 86 p.

Simi, P. (1981) Précis de géographie physique, humaine, économique, régionale, de la Corse. Collection <<Corse d'hier et de demain>>, Société des sciences historiques et naturelles de la Corse. Imprimerie Sammarcelli, Bastia, France, 608 p.

Stebbins, G.L. and Major, J. (1965) Endemism and speciation in the California flora. Ecological Monographs 35: 1–35.

Thompson, J.D. (2005) Plant evolution in the Mediterranean. Oxford University Press: New-York, 293 pp.

Chapter 11
Crete

I.N. Vogiatzakis[1] and O. Rackham[2]

The Samaria Gorge in Western Crete (Photo: Th. Arampatzis)

[1] Centre for Agri-Environmental Research, University of Reading, UK

[2] Corpus Christi College, University of Cambridge, UK

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11.1 Introduction

Crete at 8,400 km^2 is the fifth largest island in the Mediterranean (Fig. 11.1). It is much longer than its width, which nowhere exceeds 60 km. It has 15 mountain ranges, three of them more than 2,000 m high. Like other islands in this book, Crete once had a great independent civilisation, the Minoan in the Bronze Age (2900–1150 BC); although related to neighbouring islands it is distinct from mainland Greece, Anatolia, or Egypt. From the late Bronze Age onwards Crete became subsumed into the Greek world, though it retained some distinctiveness: it had its own gods who were different from those on Mount Olympus in mainland Greece. The next most conspicuous period in Cretan archaeology is the early Byzantine (AD 300–600), in which it differed less from other provinces of the Empire. In the Middle Ages, Crete was an imperial province of Venice (AD 1200–1650), and developed a hybrid of Byzantine and Venetian culture, different from other Venetian islands, though related to that of Kythera. In Ancient Greek times (700–100 BC) Crete was a collection of independent 'city-states'; since then it has been part of the Roman, Byzantine, Arab, again Byzantine, Venetian, and Turkish empires, and since 1913 part of the Greek state. Crete has often not been self-sufficient but at times it has exported olive oil, cereals, wine and cheese. For centuries it had a mixed economy. Most individual households grew cereals, legumes, vines and olives, kept sheep and goats (mainly for cheese) and often a donkey, cow and pig. Wine and oil were cash crops. Over the last three centuries oil production has gradually increased and now dominates the agricultural economy.

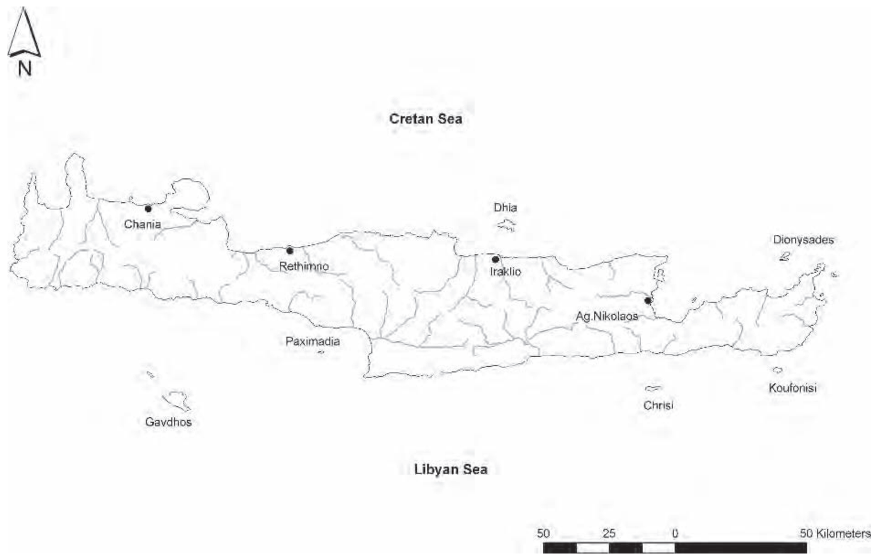

Fig. 11.1 Crete, its main towns, satellite islets and river network (Adapted from GLOBAL GIS © 2001 American Geological Institute and used with permission)

The island's population has roughly doubled since 1920, and has become increasingly urbanized (Briasoulis 2003). In the last 50 years mass tourism has become a major part of the economy: most of it is related to the coastal areas, while antiquities, wildlife and the mountains (except for the Samariá Gorge) have almost been ignored. Other changes include abandonment of terraced agriculture, increase of trees, disappearance of cereals and growth of olive cultivation, rural depopulation, proliferation of roads, introduction of greenhouses and piped irrigation (Rackham and Moody 1996). These have exerted pressure on the island's resources and habitats. Some changes (e.g. greenhouse construction) began in the 1960s; others continue processes initiated much earlier (e.g. increase in tree cover and olive groves).

11.2 Physical Environment

11.2.1 Climate

The mountains create huge regional variations in what is essentially Mediterranean climate, with rain-excesses and rain shadows. In general, aridity increases from west to east and from north to south. Annual precipitation ranges from about 240 m in the south-east to at least 2,000 m in the high White Mountains (Lefka Ori) (Grove et al. 1993). Temperature on mountains seems to fall at a rate of about 6 °C per 1,000 m (Rackham and Moody 1996). At higher altitudes precipitation increases but there is still a dry season: the growing season is limited by winter cold as well as by summer drought. Above 1,600 m most of the precipitation falls as snow that covers the ground from late October until May (or locally even July); patches on north-facing slopes may persist into July. The high mountains are limestone, into which water percolates; surface run-off occurs only after heavy rainfall or sudden snow-melt. Crete shows significant temperature gradients in west-east and north-south directions.

Almost everywhere gets at least the occasional frost. However ancient olives, which are a good indicator of the absence of severe frost, commonly occur as high as 700 m. Fog, even in summer, may be a significant factor on mountain slopes and islets (Grove et al. 1993). Although climate has fluctuated during the 20th century, there is no apparent trend. Crete has not been affected by desertification, but rather the opposite: for instance the islet of Gávdhos (Box 11.1) has changed from semi-desert to forest.

11.2.2 Tectonic History

Crete was formed by the Alpine mountain-building process that began 70 million years ago. It forms the greater part of the Hellenic Island Arc which connects Greece to Asia Minor. As the African plate has been subducted under the Aegean,

Box 11.1 Crete's Islets

Crete has about 36 offshore islets (Fig. 11.1) about which something is known, of various shapes and sizes, diverse geologically and more arid than the mainland Crete (Bergmeier et al. 2001). The majority of these islets have been linked with the history and life of Crete. Some were used for grazing and cultivation until the early 1950s. Archaeological finds on Pseira, Gaidharonisi, Kouphonisi and Dhia prove habitation in the past. Pseira claims the earliest datable terraces in Europe (2200–1700 BC); others like Imeri Grambousa, Ayioi Theodoroi have medieval chapels and castles (Rackham and Moody 1996). At present all islets but one, Gavdhos to the south-west of Crete, are uninhabited. Gaidharonisi, south-east of Crete, has been inhabited during the summer for the last 20 years due to increasing tourism. There are frequent tourist cruises during the summer months to Dhia, Ayioi Theodoroi and Ayioi Pandes facilitated and encouraged by the short distance from the coast of Crete. Some of these islets are more vegetated than others with *Juniperus macrocarpa* thickets dominating their coasts and Pseira with *Pistacia lentiscus* maquis. Others like Kouphonisi lack any trees while the islets of Dhia, Ayioi Theodoroi and Ayioi Pandes are intensively browsed due to the presence (following introduction) of the Cretan Ibex.

The islets tend to be well provided with coastal rock-plant communities, with vegetation dependent on nitrate from seabirds, and with salt marshes (such as one on Gaidharonísi described by Bergmeier and Dimopoulos (2001a). Gavdhos has a unique cultural landscape of terraces, where wheat and barley are still grown (Fig. 5.2). However, the island exhibits some of the changes taking place in Crete but they are amplified (Grove et al. 2001). Depopulation, change in cultivation and increasing pine cover are some of the most common. The most accessible islets were grazed and cultivated from mainland settlements, leaving abandoned fields and weeds (Bergmeier and Dimopoulos 2001a, b).

The floristic peculiarity of small islets in the Aegean archipelagos was recognized by Rechinger (1951). Notably, small uninhabited islands have resulted in the islet specialist species that are exclusively (or mainly) found on those islands. Some chasmophytes confined to cliffs in large islands were found colonising other habitats in small islands (Höner and Greuter 1988). The peculiarities of the satellite islets of Crete include the absence of species such as cypress and oak, both widespread in Crete, and the presence of African species such as *Periploca angustifolia, Astragalus peregrinus* that do not reach Crete (Rackham and Moody 1996). Most of the Cretan islets are included in the proposed Natura 2000 network for Greece. There are currently eight Sites of Community Importance (SCIs) where these islets are protected either on their own right or as parts of a larger area (Dafis et al. 1996).

Fig. 11.2 The fault-scarp, nearly 1,000 m high, that cuts off the east end of Crete, split by the gorge Há. August 1990 (Photo courtesy of O. Rackham)

so Crete has been uplifted, but not evenly. There have been periods of subsidence, for example, during the Miocene when the mountains of Crete became separate islands. Local faults and subsidences have created the multitude of inland cliffs and depressions that make the island's spectacular scenery, for instance the Ierápetra lowland with its towering cliffs to the east (Fig. 11.2), or the Lassíthi Plain (Hall et al. 1996). Moreover, whole mountain massifs, termed *nappes*, have slipped westwards on to lower submerged areas. This explains the repetitive landscapes of large and small mountain ranges, each of which is a nappe. Crete became an island in its present form about 2 million years ago (Legakis and Kypriotakis 1994). Changes of relative sea level during glaciations did not reconnect it to the mainland or to other islands. The island is still tectonically very active. Notches in sea cliffs, and the location of ancient shore installations, show clearly that since the Bronze Age (2900–1150 BC) the west end of the island has risen several metres, whereas the east end has sunk (Pirazzoli 1986).

11.2.3 Geology and Geomorphology

Crete is dominated by Mesozoic and Tertiary limestones, which vary widely in texture and composition (Pye 1992). Hard limestones and dolomites of the Upper Jurassic, Cretaceous and Eocene, and breccias formed from them, dominate the mountain terrain. A special feature, are the platey limestones of green and purple bands intercalated with layers of chert. About 10% of Crete is non-limestone, covered by metamorphic phyllites and quartzites. The Lefka Ori are a rugged marble and dolomitic massif, rich in scree and karst formations. There is abundant platey limestone, giving rise to cliffs and gorges at low and middle elevations. The higher parts are of black, pink and white crystalline limestones, varying in their degree of metamorphism, dolomitization and breccia formation; these give a more rounded landscape of smooth conical summits. The western Lefka Ori are a lower, less-rugged phyllite-quartzite region. Lower elevations are covered in Neogene (late Tertiary and Quaternary) deposits: marls, sandstones, clays, gravels and conglomerates, the product of erosion of the mountains during earlier stages of their uplift. Some of them are cemented together from non-calcareous rocks.

The most recent deposits in Crete are known as Younger Fill. They appear to result from catastrophic deluges, the result of the heaviest single fall of rain in a thousand or so years that swept vast quantities of sediment off slopes or out of gorges. The plains of Chaniá and Frangokástello are covered by several metres of deposit that have poured out of the gorges that penetrated the adjacent fault-scarps, burying the underlying Bronze Age and other archaeology. Many Cretan medieval churches have been buried by a metre or so of sediment deposited since they were built. Such flood deposits are associated with the Little Ice Age (AD 1300–1850) or similar events earlier in the Holocene (Moody 2005).

Karst features are produced by the dissolution of limestone and dolomite by rainwater. They include razor-edged rills a centimetre or so across; dolines, funnel-shaped hollows tens to hundreds of metres in diameter (Fig. 11.3); gorges and mountain-plains widened by karst action; and a three-dimensional underground labyrinth of caves into which the hollows drain. Karst formation begun as soon as the limestones emerged from the sea and still continues today. Karst forms more readily in crystalline limestones and breccias than in platey limestones or marls. It is promoted by low temperatures and snow-melt at high altitudes, hence the 'lunar landscapes' of dolines and fissures on the limestones and dolomites of the high Lefka Ori. Underground streams often emerge as springs at lower altitudes and provide Crete with most of its water supply. Karstification is involved in two special features of Crete, i.e. mountain-plains and gorges. Mountain-plains, such as Omalós at 1,050 m (Fig. 11.4), are a few kilometres across: they originated as tectonic grabens (areas of subsidence between faults), enlarged by further subsidence and by karst action, and partly filled by material falling in from the sides and by dust deposits. They drain either through caves or swallow holes. Crete has more than a 100 gorges, mainly in limestone, and mostly having only insignificant rivers. These originated by tectonic action and erosion, but have been widened to a greater or lesser extent by karstification. Lake Kournas at the north-west is the only sizeable

Fig. 11.3 Dolines as seen from the highest peak Pachnes (2,453 m) of Lefka Ori looking towards the Libyan Sea (Photo courtesy of I. Vogiatzakis) (*See Colour Plates*)

Fig. 11.4 The Omalos polje at 1,050 in Lefka Ori massif Crete (seen by the Koukoule Mt 1,632) (Photo courtesy of I. Vogiatzakis) (*See Colour Plates*)

lake in Crete. Other remaining wetlands include fens fed by springs, a peat bog in Asi Gonia and some seasonally wet sinkholes.

The many inland cliffs generate vast quantities of scree, consisting of angular stones split off from cliffs that pile up at the base. Frost action is important at high altitudes and is still active. Scree is also abundant at low altitudes, and may partly result from rocks weathered by daily heating and cooling cycles; many of these low-altitude screes, however, seem to be relict features and are no longer active. Scree formation has been prominent since the Tertiary, to judge by the abundant breccia limestones which are re-cemented screes. Evidence of minor Pleistocene glaciation has been identified near the top of Mount Psilorítis.

A feature of altitudes over 2,000 m in the Lefka Ori are Richter slopes, slopes at 32° which consist of solid limestone covered with a thin layer of scree (Fig. 11.5). These result from long periods of frost and karst action in the absence of vegetation. Whole summits, such as Trokháris, are 32° cones composed entirely of Richter slopes. Also special to Crete, and probably derived from some aspect of its climatic history, is cementation. Many screes are converted, in whole or in part, into concrete-like breccias. Carapaces of cemented scree encrust steep slopes. Cliffs of conglomerate or marl are covered with a layer of re-deposited limestone and look like hard rock. However, the loose contents are apt to trickle out through a breach in the crust, resulting in the jagged and hollow cliffs which are a picturesque feature of Crete. Probably because of this, badlands, the landscapes of gullies which are common in other tectonically active regions such as the northern Peloponnese,

Fig. 11.5 The High Desert on top of the Lefka Ori (White Mountains), a locality very rich in endemic plants. July 1987 (Photo courtesy of O. Rackham) (*See Colour Plates*)

Rhodes, or even the islet of Gávdhos are absent. In these regions deposits of clays and gravels, the result of erosion after earlier phases of uplift, are tilted by further uplift to angles where they are not stable and erode into gullies; in Crete they are cemented as cliffs or even overhangs.

11.2.4 Soils

Soils in Crete are typicaly weakly developed, immature and neutral to alkaline. They are sometimes formed by weathering of underlying rocks (e.g. insoluble residues from limestones), but more often involve material transported from elsewhere, especially down slopes and into basins. Another source is dust blown in the upper atmosphere from North Africa which adds 0.4–4 m of sediment per century (Pye 1992). Neogene rocks tend to form thin soils of rendzina type. Hard limestones form lithosols, shallow immature erosional soils with little organic matter. The bases of slopes have colluvial soils composed of material deposited from erosion of the upper slopes. Small karst hollows in limestone have clayey soils, sometimes of *terra rossa* type. The big dolines and mountain-plains have very varied soils related to the different kinds of fill in them.

11.3 Biotic Elements

11.3.1 Flora

The flora of Crete has been studied since the 16th century (Belon 1555). The total native flora amounts to about 1,600 species of which some 200 are endemic (Turland et al. 1993; Montmollin and Iatrou 1995). Crete is one of the hot spots of the world's biodiversity (Davis et al. 1994). Endemics are most common in the alpine zone and on cliffs, where they form much of the total vegetation, and are also characteristic of the open phrygana landscape. Like European endemics in general, they are least abundant in forest, wetland, and coastal habitats. Most of the flora has affinities with Europe. About 100 species are outliers from Asia including common trees such as cypress, Cretan pine and plane. A dozen are outliers from Africa, including wild olive.

11.3.1.1 Origin of the Cretan flora

A deposit in Neogene sediments at Makrylia in east Crete dates from the Miocene, c.8 million years ago, when Crete was submerged by some 800 m relative to the present and thus consisted of several islands. More than 100 kinds of plant remains

Fig. 11.6 The last relic of the Miocene rainforest, on the north side of Mount Kryonerítis. April 1988 (Photo courtesy of O. Rackham) (*See Colour Plates*)

can be identified, often to a particular genus. As elsewhere at this time in the Mediterranean, there was a wide variety of evergreen and deciduous trees, some of which are still represented in Crete, but others are now confined to America or the Far East. This may reflect a climate similar in temperature to the present but less seasonal, with rainfall all year round. Then as now, there was a huge altitudinal range, with vegetation zones ranging from subtropical to alpine (Sachse 2004).

The inference is that most of the Cretan flora arrived in Crete while it was still a peninsula of Europe. Since then the flora has been progressively thinned out by the increasingly arid climate and the climatic upheavals of the Pleistocene. Many plants have survived into the present without becoming fully adapted to the prevailing climate: for example, few lose their leaves in summer. The predominant lowland vegetation in Miocene times was 'laurisylvan' evergreen broadleaved forest such as now occurs in south Japan; a faint echo of it still persists in the rain-excess area of upper Apokórona and Rethymnon (Fig. 11.6).

Some of the endemics are relicts of Tertiary genera: thus *Zelkova abelicea* is now a drought-adapted representative of a genus that occurred in Miocene Crete and is still abundant in Japan. Most seem to have been cut off in Crete by rising relative sea level and subsequently to have evolved independently from their mainland relatives. Some took different evolutionary courses in the separate islands of Miocene Crete and remained independent when the islands were again linked: this is why each of the great mountain ranges has its own suite of endemics, some of which are absent from the other ranges.

11.3.2 Vegetation

Crete shares in the general categories of Mediterranean vegetation, i.e. forest, savanna, maquis, phrygana, steppe (Chapters 3 and 4) plus specialized vegetation types on cliffs, wetlands, the coast, high mountains, cultivated land and buildings. These are determined especially by moisture: by rainfall, water retention and root penetration. Thus in middle Crete, the vegetation of wide areas is limited to shallow-rooted phrygana: although rainfall is not specially low, the dense marl bedrock, though it retains moisture prevents roots from penetrating. Trees and shrubs are confined to outcrops of fissured hard limestone, or to places on the marl where a geological fault or Minoan tomb allows deep roots to reach moisture.

Maquis, phrygana and steppe often occur as a mosaic rather than as large areas of one type. This is one reason why phytosociologists have produced a bewildering and inconsistent classification for various types and combinations of these plant communities (Zohary and Orshan 1965; Barbero and Quézel 1980; Zaffran 1990). Areas of high rainfall or water-retaining rocks tend to be dominated by maquis, whereas steppe, though it occurs throughout the island, is most abundant in the south-east. The vegetation mosaic is often related either to small-scale irregularities in soil and bedrock or to the clonal growth of *Quercus coccifera* or other maquis dominants. Forest can be either outgrown maquis shrubs or continuous forest of *Pinus brutia, Cupressus sempervirens* or *Quercus ilex*, three trees which normally exist only as trees rather than shrubs. Pine tends to occur on areas of scree or soil; cypress tends to avoid soil and grow in rock fissures; holm oak is mostly on cliffs. Savanna consists of various combinations among maquis, phrygana and steppe with scattered trees. It occurs throughout the less-arid parts of the island, especially at subalpine altitudes.

Phrygana comprises assemblages of spiny, often aromatic undershrubs. Most are short-lived, shallow-rooted, distasteful and resistant to drought and grazing, such as *Calicotome villosa, Sarcopoterium spinosum, Thymus capitatus* and *Genista acanthoclada*. Traditionally they are considered to be a result of woodland ‘degradation’ due to browsing and burning (Di Castri et al. 1981). This view is now contested since it has never been illustrated by historical examples of forest turning into phrygana, nor can areas of phrygana be shown to have a history of more browsing and burning than maquis. At low and middle elevations phrygana and associated patches of steppe can contain 80–120 plant species in an $8 \times 8\,m^2$, making these ‘among the ecosystems with the highest species density in Europe’ (Bergmeier 1995). Steppe, often forming patches among maquis or phrygana, consists of many annual and perennial grasses, legumes, orchids and other herbaceous plants. Some are visible every year; others appear only after a fire.

Cliff vegetation is better developed in Crete than in any other part of the Mediterranean (Kypriotakis 1998). Cliffs are a specialized environment and provide freedom from browsing, most burning, and competition (but not woodcutting). Different types and aspects of limestone cliff (and the few non-limestone cliffs) have particular assemblages of plants. Many endemics are confined to cliffs: some, such as *Origanum dictamnus* (a medicinal herb famous since Antiquity) and *Petromarula pinnata*, are widespread. Others, such as *Hypericum aciferum*, are confined to one or a few gorges, where they have presumably been sitting since their evolutionary origin.

Given a considerable altitudinal variation, Crete has a remarkably weak vegetation zonation comprising two recognizable zones: above the tree limit (alpine zone) and below the tree limit. As on other Mediterranean Islands and small mountain ranges, the tree limit is lower than in extensive mountains such as the Alps. Usually the highest trees, reduced to only a metre or so high, but many centuries old are at c.1,600 m; in the middle Lefka Ori the limit rises to 1,810 m. Some plants have enormous altitudinal ranges, such as *Cupressus sempervirens* from sea level to the tree line, or the endemic *Verbascum spinosum* which (within a small part of the island) is common from sea level to almost 2,400 m. Many other individual plant species have upper and lower altitudinal limits, but appear or drop out one by one on ascending a mountain, without giving rise to definite zones. The alpine zone has its own variants of phrygana and steppe, and specialized plant communities on screes, late snow patches, and the floors of dolines.

11.3.3 Fauna

In the Pleistocene Crete had an elephant the size of a calf, a pig-sized, terrestrial, mountain-climbing hippopotamus (for which the classic locality is the Katharó Plain, 1,120 m above sea level), and deer, but no carnivore fiercer than a badger. The deer lost their adaptations to running, since for many generations there was nothing from which to run away. Not all these animals lived together: on present evidence there was an early to mid Pleistocene fauna comprising mini-elephant, mini-hippopotamus, giant rodents, and a giant owl. These died out and were replaced by a late Pleistocene set of ordinary-sized elephant, eight species of deer, and several mice (Rackham and Moody 1996).

This fauna would presumably have browsed the island vegetation even more intensively than the sheep and goats of historic times. Thus the native plants, especially the endemics, are adapted to avoiding or resisting browsing to an even greater degree than in the rest of the Mediterranean. Either they are confined to cliffs or they are spiny, distasteful or poisonous.

As on other islands, the native mammals may have been exterminated by early human inhabitants, although Crete has as yet no evidence of this. The island has begun to acquire a new set of peculiar mammals, such as the Cretan 'ibex' (*Capra aegagrus cretica*) now thought to be a feral population of the Neolithic domestic goat (Blondel and Aronson 1999; Rackham and Moody 1996), and possibly its own wildcat. Other mammals include hare, badger, marten and hedgehog.

Birds are those of the Mediterranean in general but also winter visitors using the island as a migration route. Crete is notable for 12 species of birds of prey including lammergeyer, griffon vulture, Bonelli's eagle and barn owl (Blondel and Aronson

1999). Among invertebrates there are many endemics, especially in the mountains (Legakis and Kypriotakis 1994; Sfenthourakis and Legakis 2001).

11.3.4 Vegetation History

Palaeolithic or Mesolithic people could have visited Crete and affected its ecology, but if they did they left no known archaeological record (Chapter 3). The earliest evidence of human presence is Neolithic, of about 6600 BC. Humanity has altered Crete by exterminating native animals (if any still survived), creating farmland, introducing crops, weeds and plant diseases, introducing domestic livestock and other animals, woodcutting, and altering the frequency of fire. As elsewhere in the Mediterranean the impact of these is more equivocal than in other parts of the world and is often difficult to distinguish them from the parallel aridization of climate (Chapter 3).

For Crete there are seven pollen diagrams, covering the period from before the Neolithic to the present (Fig. 3.4). Unfortunately they are from different landscapes within the island, each with its own vegetation history; no single site covers the whole period. Generally the pollen records imply a less-forested landscape than in northern parts of the European Mediterranean (Chapter 3). The 'aboriginal' vegetation of Crete was not continuous forest but often consisted of maquis or savanna. Phrygana plants and others (like *Asphodelus*) which do not flower in shade are already present in the earliest samples. Trees have decreased at some times and increased at others, but on no consistent pattern. In the early Holocene the climate appears to have been less arid, and north European trees and other plants, such as *Tilia* and *Alnus*, extended even to Crete. These died out gradually over a long period, and a few (such as *Ulmus* and native *Vitis*) still survive in especially damp environments. Evergreen oak (in Crete mainly *Quercus coccifera*) tended to increase at the expense of deciduous oak. Phrygana, at first already abundant in the dry Akrotíri Peninsula on the north coast, tended to increase elsewhere.

Judging from the pollen diagrams, the present vegetation types of Crete are not human artefacts, but extend back for most of the Holocene. Human influence has altered their proportions, but has not eliminated some types of wild vegetation nor created others (Chapter 3). Forest has never for long been much more abundant than it is now, and was not especially prominent in Classical times (480 BC–AD 380). *Cupressus*, regarded for 2,500 years as the special tree of Crete, did not extend into regions where it no longer occurs. The earliest unambiguous evidence of human activity in the pollen is the appearance of large amounts of olive pollen in the late Neolithic.

Crete has fragmentary written information in the late Minoan, Greek and Roman periods, most of which is consistent with a landscape not very different from that of a century ago. The main types of wild vegetation today would be recognized by any Cretan from the Bronze Age onwards. From the 13th century

AD onwards, documentation in Venetian and Turkish archives and in the accounts and pictures of travellers becomes more copious and specific, often referring to specific places. There are indications of local changes: at times there have been rather less forest, more wetland, more cultivation, and more grassland than there is now. However, the proportions of forest, savanna, maquis, phrygana and steppe have not radically changed; this may be an indication of resilience rather than stability.

Unlike the endemic mammals, which are nearly all extinct, Crete still has almost all its known endemic plants. It must not be assumed that all the Holocene flora still survives. Out of a 100 or so non-tree plants that have left a pollen record, six are not known living (Chapter 3). There is no way of telling how many of these were endemics, or whether they disappeared because of Aridization or human action.

11.4 Cultural Landscapes

11.4.1 Settlement

In about 60% of Crete settlement takes the form of villages, settlements of hundreds of people spaced 3–5 km apart. In the rest of the island, especially in the west, settlement is dispersed in the form of hamlets, settlements of dozens of people, 1–2 km apart (Fig. 3.6). Hamlet landscapes occur on other islands such as Kythera and Corsica, but are very rare elsewhere in Greece. In Crete the hamlet pattern is the older and has been gradually displaced by villages over the last 1000 years. Villages, hamlets and towns have alternated at various dates from Minoan to Byzantine (Chapter 3). As on other islands the present concentration of settlement on the coast is no more than 120 years old. In previous periods people avoided living on the coast whenever piracy was prevalent (Chapter 3).

Crete has at least 3,000 medieval churches, probably the biggest concentration in the world. They are nearly all small; typically a village has several churches and a hamlet has at least one. Medieval Christian churches are particularly numerous in regions, such as Selinon, with a later Muslim history. This pattern of churches seems to be peculiar to Crete and a few other islands in the medieval period. Previously there had been much bigger Christian Roman basilicas, the equivalent of parish churches (a very few of which are still in use). Even these bear little relation to the sacred sites of Ancient Greek or Minoan times (Nixon 2006).

Nearly the whole of Crete is private property. Even the high mountain pastures of west Crete are divided up between landowning families; Psiloritis, however, is said to be common land in which families have intermingled grazing rights.

Fig. 11.7 Terracing: an extreme example of vines grown on terraced slopesof more than 45°. Thryphtí Mountains, east Crete, May 1989(Photo Courtesy of O. Rackham)

11.4.2 Rural Infrastructures

Crete is a terraced island. Terraces are almost everywhere, except where unstable geology would risk slumping; they reach into the mountains far above the present limits of cultivation, and to offshore islets (Fig. 11.7) (Box 11.1). Terraces are difficult to date; they probably reached their greatest extent in the 19th century. Ancient trees growing on terraces enable some to be dated into the Byzantine or even Ancient Greek period.

Fields are bounded by dry-stone walls (rarely hedges). Enclosures are of many different types, from those that divide the fertile floors of mountain-plains to the huge enclosure walls that bound some mountain pastures. Some form coherent systems laid out by ancient planners: the plain of Chania is covered by a planned system of fields laid out between slightly diverging north–south axes, apparently after catastrophic mud flows has buried the plain and its earlier property boundaries. The Lassithi mountain-plain is still divided into 193 rectangles laid out by late-medieval Venetian surveyors. Parts of the Mesara plain used to have long narrow strip-fields reminiscent of those widespread in northern Europe and in Sardinia.

Crete had a very well-developed network of paved mule tracks, extending even into the high mountains, built probably in the Venetian period (1210–1650) and maintained during the Turkish period (1650–1898).

11.4.3 Human Influences on Wild Vegetation

People have altered the extent of semi-natural vegetation by making new fields out or letting abandoned fields revert to the wild. They have altered the remaining wild vegetation by keeping domestic animals, woodcutting, burning, and by going into the mountains to 'domesticate' wild olive and pear trees by grafting them to cultivated varieties. Cretan vegetation either is adapted to these practices or escapes them by growing on cliffs. The response varies from one plant species to another. Forest or savanna can turn into maquis and revert to forest or savanna when browsing is relaxed for a few years.

Browsing affects different trees and plants according to their palatability and their ability to recover. Goats' preferences range from wild olive (very palatable) to pine and cypress (least palatable). *Quercus coccifera* is moderately palatable but very resilient: it can take any form from a big oak tree to a shrub a few centimetres high, and changes from one to the other according to circumstances (Fig. 3.1c, 3.2a). Most of the common undershrubs of phrygana are relatively unpalatable (spiny or distasteful), but some are killed by browsing and grow on cliffs. For example, the endemic undershrub *Ebenus cretica* is very palatable, and an effect of the decline of browsing is its appearance away from cliffs. Many steppe plants, especially legumes and *Compositae*, are palatable and browsing-adapted; others are poisonous or grow on cliffs.

Throughout Europe, trees have been cut for wood (i.e. firewood, charcoal and light construction) or timber (beams and planks) either at ground level (*coppicing*) or 3–4 m above ground (*pollarding*). All Cretan trees respond by sprouting from the stump or from the roots (*suckering*). Woodcutting was once of great importance among wild trees, as shown by the prevalence of big ancient coppice stools of oaks, cypresses and many other trees. Such stools are to be found even on cliffs where climbing ropes would have been needed to get at them.

Most of the island's vegetation is combustible and fire-adapted; especially fire-promoting are young pinewoods and the dense strawberry tree thickets (*Arbutus unedo*) of non-limestone areas. Most trees, such as *Quercus coccifera*, survive fire; they may be killed to the ground but sprout, although the sprouts are attractive to browsing animals and recovery may be delayed. Among conifers, *Pinus brutia* is killed by a fierce fire but comes again from seed; cypress and *Juniperus phoenicea* are non-flammable but killed by a fire if it occurs around them. Most undershrubs (except *Ebenus*) are killed by fire but return from seed. Occupational burning every few years, to reduce the undershrubs and improve the pasture, has been linked to shepherding for centuries if not millennia. Burnt areas generally have the richest flora, with many annuals and short-lived perennials sprouting from seed laid down after the last fire.

The effects of humans on Cretan wild vegetation are difficult to summarize because of ignorance about what would happen without them. From the Pleistocene history of the island's mammals it is reasonable to infer that the island has been at least as severely browsed as it is now for most of the last 2 million years. The natural fire regime, before settlement, is unknown but could easily have been fiercer than after settlement, with less frequent but hotter burns. Changes in recent decades, as some forms of human activity have declined, illustrate the range of possibilities, but it must not be assumed that withdrawing activity results in the same state as if that activity had never happened. The decline of deciduous oak relative to evergreen oak since the mid-Holocene can be attributed to it occupying the soils that were worth cultivating; this is now being reversed as some of those lands are abandoned.

People have also created new habitats. Some cliff endemics, such as *Petromarula pinnata* but not *Origanum dictamnus*, will grow on artificial cliffs and are common on medieval buildings. The city flower of Heraklion is *Hyoscyamus aureus*, which for at least 400 years has been growing on the Venetian city walls, its only locality in Europe.

11.4.4 Ancient Trees

Crete is outstanding in Europe for its ancient trees of many species, which are important components of historic landscapes and archaeological features and provide a unique habitat for animals and plants. Nearly all have some connexion with human activity. Some are cultivated, for example, ancient olives, a few being over 2,000 years old, occur in most parts of the island, and chestnuts up to 700 years old occur in remote parts of the western mountains. Mountain plains have gigantic pollarded 'domesticated' pears (*Pyrus amygdaliformis*). Woodcutting prolongs the life of a tree; some of the oldest trees are huge coppice stools of cypress and *Quercus ilex*; others are giant pollards of *Q. coccifera* and the endemic *Zelkova abelicea*.

11.5 Recent Landscape Changes

It must not be supposed that the 'traditional' landscape of Crete was necessarily stable. There have been technological changes in the past, such as the introduction of barrels around the 14th century AD. Some 20th-century changes have their origins further back: the increase in olives came on top of past increases which began in the 16th century. Nor should changes in land use be confused with changes in landscape: terraces built for growing cereals may have been later used for vines and later still for olives.

As in most Mediterranean countries, the population steadily rose from about 1840 onwards and continues to rise albeit less rapidly. At first the rise was mainly rural, but later the urban population overtook the rural, as cities expanded, villages grew into towns, and the coast became safe to live on. According to census data, rural population reached a peak around 1950, somewhat earlier in hamlets and later in the bigger villages; only coastal settlements and those within commuting distance of cities have grown since. Such trends are however partly masked by the

Fig. 11.8 Expansion of greenhouses at Falassarna, West Crete (Photo courtesy of G. Kazakis)

tendency of Cretans to have two homes and by the tendency of fewer people than formerly to live in a house.

Crete was developed as a place of mass tourism in the 1970s and 1980s. With the exception of the Balearics, Crete is now the most touristic of the large Mediterranean Islands. Development is almost exclusively coastal and has come to occupy much of the north coast, with scattered developments on other coasts.

11.5.1 Agricultural Changes

During the 20th century agriculture contracted and became less diverse. Cereal and legume growing have almost disappeared. Olives became the most extensive crop, and the annual crops are no longer grown between the trees. Oranges, kiwi fruit, and other tropical crops are now the main alternative to olives in lowland valleys where frost is rare. Vine growing has become more concentrated in the centre of Crete. These changes are related to the introduction of bulldozers, plastic greenhouses and piped irrigation (Fig. 11.8).

The bulldozer came to Crete in the 1960s and was used as an instrument of cultivation, carving out false terraces from soft-rock hillsides which now make up several per cent of the island's area. This was the start of a further extension of olive growing. Much of this was on land that had previously been cultivated, but bulldozing has encroached on wild vegetation, especially on soft metamorphic rocks in west Crete. The false terraces do not have retaining walls but stand up as best they may. The bulldozer also transformed road making. Early vehicle roads, beginning in the 19th century, were solidly built with retaining walls. From the 1960s roads were merely dug out of the hillside. Bulldozing, which occurs on other islands on a smaller scale, has been a particular Cretan activity that has destroyed archaeology, damaged the vegetation, and greatly increased the risk of erosion.

Market gardening in plastic greenhouses began around 1965 and is now the most extensive form of agriculture after olive growing, especially in the western Mesará and around Ierápetra. Irrigation from ditches and canals is an ancient but localized practice that was intensified in the early to mid-20th century. To facilitate it, ancient field systems were swept away in a fashion for 'rationalization' in the 1950s. From the 1970s onwards the introduction of plastic pipes made irrigation possible (and more efficient) on a much larger scale, up to the limit of the available water and up to an altitude of around 1,200 m. All the lowland crops, including olives and vines, are now irrigated. The water use led to the drying up of rivers, to boreholes, and in the 1980s to dam building. To date salinity and contamination seem not to have been a problem but agricultural excesses have brought other damage: pollution of karst aquifers and the remaining watercourses with fertilizers, weedkillers and olive-processing waste; and the disposal (or non-disposal) of thousands of tons of rotten greenhouse plastic.

The driving force for these changes has been technology, rising numbers of tourists requiring food, and better communications for exporting produce. Most of the changes were well advanced before Greece joined the European Union in 1982. Since then, European Union subsidies have tended to intensify agricultural development, to the point of over-production of olive oil and oranges (Fig. 11.9) Crete also has a record of diverting subsidies to improper uses, such as agricultural subsidies used for building hotels, or grazing subsidies used for converting semi-natural vegetation to agriculture (Briasoulis 2003)

11.5.2 Vegetation Changes

The area of semi-natural vegetation in Crete has increased in the last 150 years, since more farmland has been abandoned in the mountains than has been taken in at low altitudes. Agricultural terraces have become pasture, maquis, or forest. Crete lost almost all its cattle, pigs and mules in the early to mid-20th century. Before 1950 sheep and goats were everywhere; since then they have been concentrated in certain areas and have disappeared from others, while the area available to them has increased. Official statistics appear to show a general increase, but are difficult to reconcile with numbers of actual animals.

The resulting decline in browsing has resulted in a widespread but variable increase of semi-natural vegetation. Maquis trees overgrazed to shrub status have grown up into forest; savannas have infilled into forest; trees have arisen

Fig. 11.9 Destruction of maquis on metamorphic rocks in west Crete, the object being to add to the already excessive production of olive oil. Vatólakkos, west Crete, May 1992 (Photo courtesy of O. Rackham) (*See Colour Plates*)

from seed in abandoned farmland. In many parts of Crete forests of young trees on old cultivation terraces were certainly not there in 1950. Elsewhere, a comparison of World War II aerial photographs with what is there now shows little change.

Much of the increased vegetation consists of fire-promoting species such as pines. Consequently, as in Corsica there has been an inevitable increase in fire. The 'traditional' pattern of small-scale burning by shepherds has been replaced by hot, extensive, uncontrollable wildfires. For example, at Myrtos west of Ierapetra browsing largely ceased in the 1940s and the mountains became invaded by *Pinus brutia*. A conflagration was anticipated (Rackham 1990) and duly happened in 1994.

On the northern Psilorítis massif, the territory of the giant village of Anóyeia, pasturage has become intensified. In the past, shepherds were constrained by the carrying capacity of the land; if the animals ran short of food they stopped producing milk. Now hay can be brought in from outside (Papanastasis et al. 2004). Excellent road communications have removed the natural limit on overgrazing.

Woodcutting has virtually disappeared; Crete gets nearly all its wood as a by-product of olive growing. Wetlands, never extensive, have particularly suffered from draining and building, or in some places from draining followed by abandonment.

Crete, however, has not had many huntable animals since Roman times, and small birds are less eaten than they used to be. The Cretan ibex, which has been shot down the centuries, suffered especially from the introduction of rifles, and there are still reports of poaching (Dafis et al. 1996).

11.5.3 Introduced Plants and Animals

People have been adding to the wildlife of Crete, e.g. feral goat, rat, carob tree, for the last 7,000 years. Additions have been more frequent in the last 100 years. *Oxalis pes-caprae* from South Africa has become one of the commonest plants in the island. The Chinese tree *Ailanthus altissima*, probably introduced by Sir Arthur Evans, has been widely planted and threatens to overrun the archaeological site at Knossos. Recent arrivals include *Paspalum* species, grasses that are universal tropical weeds and have become abundant in orange groves, and roadside plants such as *Hirschfeldia incana* and *Conyza albida* that have taken advantage of the boom in road making. As in most of Europe, vine growing has been complicated by the introduction of American vine diseases: downy mildew, powdery mildew and phylloxera.

11.6 Conservation and Future Needs

In the 1990s, Crete appeared to be a typical example of conflict between conservation and development. Local governmental agencies had conflicting land-use policy objectives. The Forest Service had difficulty in managing and protecting the maquis because there was pressure from the local population, and subsidies from the Ministry of Agriculture, to bulldoze them into irrigated olive groves (Papanastasis et al. 2004). Later the subsidies were suspended, but the local Agricultural Service still favoured these conversions (Grove and Rackham 1993).

What of the future? It is important to distinguish between changes and threats. Occupational fires and catastrophic deluges are part of the normal dynamics of landscapes and are not a threat; conflagrations and the spread of introduced species are outside normal dynamics and are a threat. Threats for the future are not just an extrapolation of changes in the past.

Most kinds of development reached their maximum growth around 1990; they continue to advance, but less rapidly. Some of their effects have not yet worked themselves out. Seaside hotels and hardened seafronts will destroy the beaches that their livelihood depends on. The full consequences of bulldozing will become apparent the next time there is a rare high-rainfall event. A new threat has arisen, in the form of American-style golf courses, which are unsuited to the climate, users of large areas of land, and prodigal wasters of water.

Crete has so far escaped the worst effects of introduced plants. *Pinus halepensis*, even more fire-promoting than the native *Pinus brutia*, has been widely planted but has not spread. The eucalypt plantations which have poisoned and burnt much of Sardinia and Kythera are absent from Crete. *Oxalis* may have subtracted some of the flora of olive groves, but has already reached its limits and is no longer a threat. However, *Ailanthus* appears to be uncontrollable and may turn in the long-term Cretan villages into forest. The planting of *Carpobrotus edulis*, an aggressive and unattractive plant from South Africa, on the city walls of Heráklion threatens their distinctive historic plant cover.

New or introduced diseases are probably the most serious long-term threat to Europe's trees (Rackham 2006). There is no effective way of keeping them out, but so far Crete has escaped their worst effects. The native cypress seems to be unaffected by the disease that has ravaged planted cypresses all over Europe. A pine adelgid insect is killing pines on the south side of the Lefka Ori, but whether it is native, and whether this is within normal dynamics, remains to be seen. However new or introduced diseases are probably the most serious long-term threat to Europe's trees, and there is no effective way of keeping them out of Crete.

11.6.1 Threats to the Special Features of Crete

Endemic plants are less threatened than might be expected. Although 238 species are listed as locally threatened (Chapter 4), this usually means that their populations are small rather than that circumstances have changed. Most of them are on cliffs, or on high mountains where pressures on land are low. Low-lying shores, where development pressures are greatest, have few distinctive plants, but are very significant for birds and turtles. The few remaining and severely threatened wetlands are also important bird sites, e.g. Georgioupolis, Kourna, Ayia.

Most gorges, being in porous limestone, have been so far protected, although the growth of the village of Therisso will create a potential threat to the gorge beneath it, one of the most significant in Crete, through road-widening. Dam building, however, is a continuing threat to the few non-limestone gorges; dams also destroy antiquities and create an earthquake hazard.

Conflagrations, will continue to increase. Where browsing no longer dominates a landscape, fire inevitably replaces it. Two places of particular hazard, due to the increase of pines, are the Samariá Gorge and the islet of Gávdhos. Wildfires are especially a threat to the ancient and historic trees that are special to Crete.

11.6.1.1 Protected Areas

The Samariá Gorge and surrounding mountains (48 km^2) have been a National Park since 1962. The reason for its designation was mainly the protection of the Cretan 'ibex'. The Park covers from 100 to 2,100 m, with habitats ranging from steppe to forest to alpine dwarf vegetation with many endemic plants. It is not

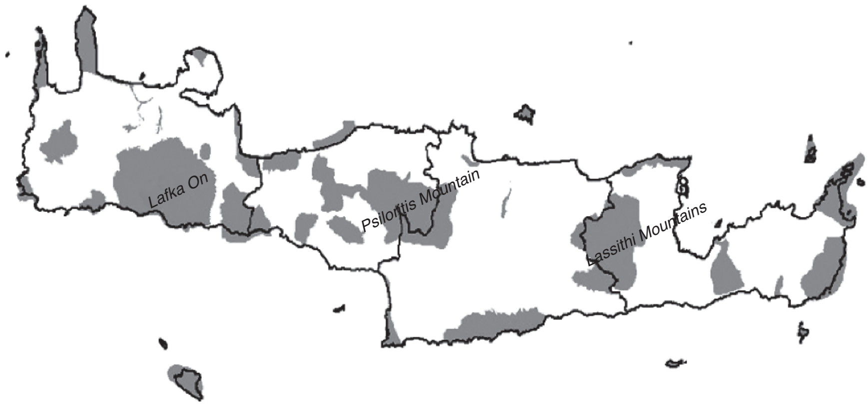

Fig. 11.10 Sites of Community Interest (SCIs) in Crete

wilderness, having been inhabited since prehistoric times, and has a special place in Cretan cultural history. The inhabitants and their livestock were banished in 1962 and no human activity was permitted except tourism, in accordance with the philosophy of National Parks at the time. With the withdrawal of human activity, the buildings have decayed and the landscape has become overgrown with forest, especially of pine. This creates the risk of an unprecedented and disastrous conflagration which would destroy the ancient trees and other features of the cultural landscape.

Three islets off the north coast were designated as nature reserves in the 1920s, and small numbers of ‘ibex’, then thought to be in danger of extinction, were transferred to them. The animals fared surprisingly well and created a highly browsed ecosystem, to the detriment of the islands’ peculiar flora. The largest stand of the Cretan palm (*Phoenix theophrasti*), a relict endemic of the south Aegean, at Vaï near the north-east tip, is protected and monitored by the Forest Service. The larger archaeological sites, such as Gortys, also act as wildlife reserves.

11.6.1.2 Protection of the Rest of Crete

Under the Natura 2000 European network 28 areas in Crete have been proposed for protected Sites of Community Interest (SCIs) (Fig. 11.10). Thirteen of those areas are in mountain massifs. Other designations include gorges rich in endemics such as Thérisso in western Crete and Kourtaliotis in the South. However, mountains and gorges are among the least threatened parts of the island.

Old-fashioned human activities, especially grazing, are an essential part of most historic ecosystems in Crete and must be continued in nature reserves. Failure to realize this will not only result in opposition from the people affected, making the scheme unworkable, but is counterproductive in itself. Any interference with land ownership will be particularly resented. The objective should be to take a middle course between withdrawal and intensification, both of which are detrimental to natural ecosystems. Neither the Samariá nor the Anóyeia story should be repeated on other mountains. Biomass that is not grazed will be consumed by fire. Another problem is that some ecosystems, such as savanna, result from past fluctuations of management which are difficult to legislate for in the future.

As far as the rest of Crete is concerned, the best scenario is the gradual introduction and proper enforcement of planning procedures, and proper environmental impact assessment of schemes such as roadworks, dams, and power stations. In 1981 there was a presidential decree (No. 67/1981) on the protection of rare plant and animal species in Greece but whether it had any effect is uknown (Kassioumis 1994). The ordinary maquis-phrygana-steppe of Crete although still abundant is undervalued. There is an erroneous idea that it is a 'degraded landscape'; as such it becomes a target for low-density development, golf courses or marginal agriculture.

Most tourists visit Crete for the seaside; this may be illogical, for the Cretan coast is not very different from other Mediterranean coasts, but it has had the effect of concentrating development in the less distinctive and attractive parts of Crete. Visitors should be encouraged to take more interest in the antiquities and the mountains and in Cretan culture in its own right. They should come outside the summer and appreciate what in spring and autumn are among the world's most beautiful landscapes.

References

Barbero, M. and Quézel, P. (1980) La végétation forestière de Crète. Ecologia Mediterranea 5: 175–210.

Belon, P. (1555) *Les observations de plusieurs singularitez et choses memorables trouvées en Grèce, Asie, Judée, Egypte, Arabie et autres pays étrangèrs.*

Bergmeier, E. (1995) Die Höhenstufung der Vegetation in Südwest-Kreta (Griechenland) entlang eines 2450 m-Transektes. Phytocoenologia 25: 317–361.

Bergmeier, E. and Dimopoulos, P. (2001a) Flora and phytogeographical significance of the islands Chrisi, Koufonisi and nearby islets (S. Aegean, Greece). Wildenowia 31: 329–356.

Bergmeier, E. and Dimopoulos, P. (2001b) Chances and limits of floristic island inventories – The Dionysades group (South Aegean, Greece) re-visited. Phyton 41: 277–293.

Bergmeier, E., Kypriotakis, Z., Jahn, R., Böehling, N., Dimopoulos, P., Raus, T. and Tzanoudakis, D. (2001) Flora and phytogeographical significance of the islands Chrisi, Koufonisi and nearby islets (S. Aegean, Greece). Wildenowia 31: 329–356.

Blondel J. and Aronson J. (1999) Biology and Wildlife of the Mediterranean Region. Oxford University Press.

Briasoulis, H. (2003) Crete: endowed by nature, privileged by geography, threatened by tourism? Journal of Sustainable Tourism 11: 97–115.

Dafis, S., Papastergiadou, E., Georghiou, K., Babalonas, D., Georgiadis, T., Papageorgiou, M., Lazaridou, T. and Tsiaoussi, V. (eds.) (1996) The Greek 'Habitat' project NATURA 2000: an overview. Commission of the European Communities DG XI. Directive 92/43/EEC. The Goulandris Natural History Museum – Greek Biotope/Wetland Center, Thessaloniki, Greece.

Davis, S.D., Heywood, V.H. and Hamilton, A.C. (eds.) (1994) Centres of Plant Diversity. WWF/IUCN: Cambridge.

Di Castri, F., Goodall, D.W. and Sprecht, R.L. (1981) Mediterranean Type Shrublands. Elsevier: Amsterdam.

Grove, A.T. and Rackham, O. (1993) Threatened landscapes in the Mediterranean: examples from Crete. Landscape and Urban Planning 24: 279–292.

Grove, A.T., Moody, J. and Rackham, O. (2001) Gavdhos, Crete. In B. Green and W. Vos (eds.). Threatened Landscapes: Conserving Cultural Environments. Spon Press: London, pp. 69–79.

Grove, A.T., Ispikoudis, I., Kazaklis, A., Moody, J.A., Papanastasis, V. and Rackham, O. (1993) Threatened Mediterranean Landscapes: West Crete: University of Cambridge.

Hall, R., Audley-Charles, M.G. and Carter, D.J. (1996) The significance of Crete for the evolution of the Eastern Mediterranean. In J.E. Dixon and A.H.F. Robertson (eds.) The Geological Evolution of the Eastern Mediterranean, pp. 499–516.

Höner, D. and Greuter, W. (1988) Plant population dynamics and species turnover on small islands near Karpathos (South Aegean, Greece). Vegetatio 77: 129–137.

Kassioumis, K. (1994) Nature conservation in Greece (legislation and administration of parks and reserves). Parks 12(2): 14–15.

Kypriotakis, Z. (1998) Contribution to the study of the chasmophytic flora of Crete and to its utilization as a natural resource, to the direction of ecotourism, floriculture, ethnobotany and Protection of threatened plant species and their biotopes. Doctoral dissertation, University of Patras. In Greek.

Legakis, A. and Kypriotakis, Z. (1994) A biogeographical analysis of the island of Crete, Greece. Journal of Biogeography 21: 441–445.

Montmollin, de B. and Iatrou, G.A. (1995) Connaissance et conservation de la flore de l' île de Crète. Ecologia Mediterranea 21: 173–184.

Nixon, L. (2006) Making a Landscape Sacred: Outlying Churches and Icon Stands in Sphakia, Southwestern Crete. Oxbow: Oxford.

Papanastasis, V., Ispikoudis, I., Arianoutsou, M., Kakouros, P. and Kazaklis, A. (2004) Land-use changes and landscape dynamics in Western Crete. In S. Mazzoleni, G. di Pasquale, M. Mulligan, P. di Martino and F. Rego (eds.) Recent Dynamics of the Mediterranean Vegetation and Landscape. Wiley: Chichester, pp. 81–93.

Pirazzoli P.A. (1986) The Early Byzantine Tectonic Paroxysm Zeitschrift für Geomorphologie NF Suppl. 62: 32–49.

Pye, K. (1992) Aeolian dust transport and deposition over Crete and adjacent parts of the Mediterranean sea. Earth Surfaces and Landforms 17: 271–288.

Rackham, O. (1990) The greening of Myrtos. In S. Bottema, G. Entjes-Nieborg and W.v. Zeist (eds.) Man's role in the shaping of the eastern Mediterranean landscape. Balkema: Rotterdam, 341–348.

Rackham, O. (2006) Woodlands. Harper Collins: London.

Rackham, O. and Moody, J.A. (1996) The Making of the Cretan Landscape. Manchester University Press: Manchester.

Rechinger, K.H. (1951) Phytogeographia Aegaea. Denkschr. Akad. Wiss. Wien 105(2,2): 208 pp.

Sachse, M. (2004) Die neogene Mega- und Mikroflora von Makrilia auf Kreta und ihre Aussagen zur Klime-und Vegetationsgeschichte des östlichen Mittelmeergebietes. Verlag Documenta naturae, München 2004.

Sfenthourakis, S. and Legakis A. (2001) Hotspots of endemic terrestrial invertebrates in southern Greece. Biodiversity and Conservation 10: 1387–1417.

Turland, N.J., Chilton, L. and Press, J.R. (1993) Flora of the Cretan Area: Annotated Checklist and Atlas. HMSO: London.
Zaffran, J. (1990) Contributions à la Flore et à la Végétation de la Crète. Université de Provence, Aix en Provence.
Zohary, M. and Orshan, G. (1965) An outline of the geobotany of Crete. Israel Journal of Botany 14, supplement.

Chapter 12
The Balearic Islands

M. Morey[1] and M. Ruiz-Pérez[2]

Ancient olive groves in the Balearics; (Photo: Maurici Ruiz)

12.1 Introduction

The Balearic Islands comprise 151 islands and islets (counting all of those of more than 100 m in maximum length) with a total area of 5,061.3 km^2 and a coastline length of 1,238.9 km. The four inhabited islands, Mallorca, Minorca, Ibiza and Formentera,

[1]Department of Biology, University of the Balearic Islands, Spain

[2]Instituto Mediterráneo de Estudios Avanzados (IMEDEA), Spain

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represent more than 99% of the total surface area (Fig. 12.1). Ibiza and Formentera are close lying neighbours, and form the Pityusic sub-archipelago. The ancient Greeks called Mallorca and Minorca the Gymnasiae or the Balyares Islands, and Ibiza and Formentera the Pityusic Islands; later, the Romans referred to these four main islands and their outlining islets as the Balearics. Currently the name of Balearics is applied to the entire archipelago, and the name Pityusic to Ibiza and Formentera. The four inhabited Balearic Islands are very different in size, population density, and other basic traits as shown in Table 12.1.

Although the average distance of the archipelago from the continent is about 150 km (minimum 50 km, maximum 240 km), this has produced a biological, historical and cultural isolation. Humans reached these islands about 4,000 years ago in the

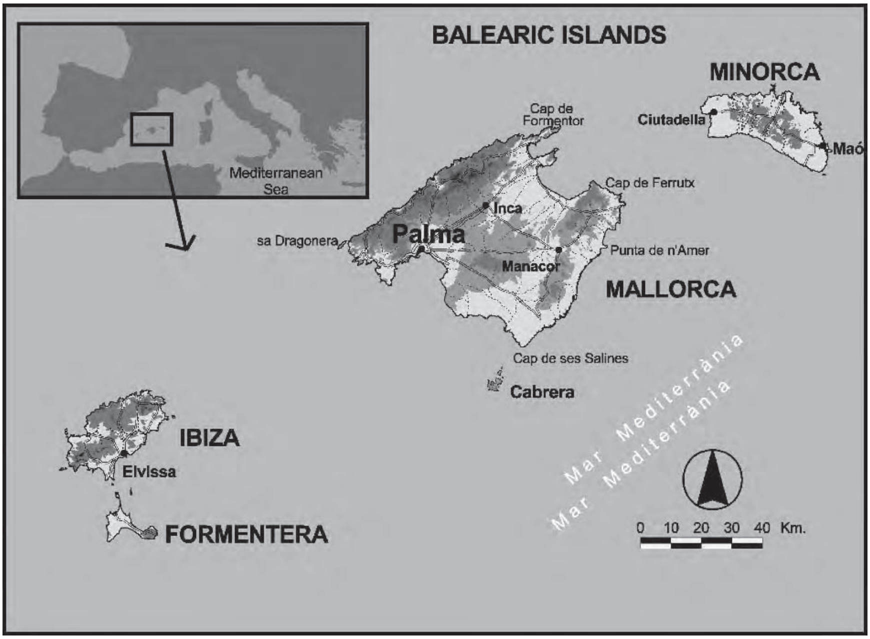

Fig. 12.1 Location of the Balearic Islands at the Mediterranean Basin

Table 12.1 Main statistical data for the Balearic Islands (After Morey and Martínez-Taberner 2000)

Island	Population* (%)	Extension (km^2) (%)	Coastal length (km) (%)	Maximum Altitude (m)	% Area 0–100 m altitude
Mallorca	740,925 (80.5%)	3,640 (72.6%)	554.7 (49.5%)	1,445	46.9
Minorca	76,330 (8.3%)	716 (14%)	285.7 (25.5%)	350	76.5
Ibiza	95,194 (10.3%)	572.6 (10.8%)	210.1 (18.8%)	476	47.3
Formentera	7,712 (0.8%)	83.2 (1.6%)	69 (6.2%)	192	92.0
Balearics	920,161	5,012	1,119.5	1,445	51.9

*Population refers to 2003.

Neolithic Age. Before the Roman domination (123 BC), the Balearic people built megalithic buildings, the 'talaiots', similar to the 'nuraghi' of Sardinia, or the 'taulas' and 'navetes', characteristic of Minorca. The Balearics were successively conquered by Greeks, Phoenicians, Romans, and different Arabic peoples. In 1229, King James I of Aragon conquered Mallorca and four years later Ibiza. Minorca was not incorporated in the Aragon Kingdom until its conquest by Alfonso III of Aragon in 1287. Since then, and apart from a short period as a free kingdom, the Balearics have been part of Spain. In the early 1960s development of mass tourism affected the physical, social, economic and cultural fields and generated important landscape changes. As part of Spain, the Balearics currently enjoy 'Autonomous Community' status with a high level of self-government. Furthermore, Mallorca, Minorca Ibiza and Formentera have their own political-administrative status called the 'Consell', although Formentera is only considered a Municipality of the Pityusic Archipelago.

As well as sharing the common traits of all the Mediterranean Islands, such as climate, scarcity of available water, frequency of wild fires, etc. (Brigand 1991; Morey and Martínez-Taberner 2000; Grove and Rackham 2001), the Balearic Islands present two specific characteristics: high landscape diversity, both for all the archipelago and for Mallorca, and intensive mass tourism development, known as 'balearización''.

Landscape diversity is a product of the differences in geology, relief, coastal variation, climate and vegetation. These differences are reinforced by distinct cultural traits, which in turn, can be attributed to the differences of each island's historical occupation.

Minorca is a flat 'green' island, with a cover of natural woodlands and North European style semi-natural non-irrigated pastures for sheep and cattle in extensive properties locally known as 'llocs'. The island also has extensive beaches and natural harbours. It has been inhabited since prehistoric times, with ancient villages and the cities of Mahón and Ciudadela, situated by the island's two natural harbours. These advantageous harbours have allowed these cities to remain in commercial and cultural contact with Mallorca and the mainland, and maintain a traditionally solid economic and cultural level, especially since the British rule during the 18th century.

Formentera is a flat, semi-desert island, with sparse vegetation dominated by aromatic dwarf shrubs: with scattered 'sabinas' (*Juniperus phoenicea*), the most common and representative tree of the island, and aleppo pines (*Pinus halepensis*). Until the development of tourism, the economy was based on small rural properties, with poor extensive grain crop agriculture alternating with goat and sheep-herding and family-fishing operations. The only industry on the island was salt production in marine saltpans. Although inhabited since prehistoric times, because of its harsh living conditions for human survival, it has been alternately inhabited and abandoned, until the last resettlement 300 years ago.

Mallorca and Ibiza are similar with respect to their landscapes; except that Mallorca has a mountain ridge, the Serra de Tramuntana, parallel to the coast from the North to the West, with many steep mountains that rise above the 1,000 m elevation mark. With respect to their cultural history, Ibiza has been influenced by Punic (Carthaginian), as well as Arab domination, whereas Mallorca was mainly influenced by the Romans.

Table 12.2 Present status of the Balearic Islands for population and tourism development (After Morey and Martínez-Taberner 2000. With statistical data of 2003.) PD = Population density, AB = Accommodation beds (%), AB/CL = Ratio of accommodation beds/coastal length, NA = Number of airport arrivals, NA/CL = Ratio of number of airport arrivals/coastal length.

Island	PD	AB (%)	AB/CL	NA (%)	NA/CL
Mallorca	203.6	283,436 (67.7)	511.0	9,592,827(70.9)	17,294
Minorca	106.6	47,319 (11.3)	165	1,352,019 (10.0)	4,732
Ibiza	166.2	80,363 (19.2)	382.5	2,078,260(15.4)	9,892
Formentera	92.7	7,697 (1.8)	111.6	510,990 (3.8)	7,405 (*)
Balearics	192.6	418,815	347.0	13,534,105	10,923

Therefore, each of the Balearic Islands has a distinct character. Due to its larger size and differences in relief and climate, Mallorca has considerable landscape diversity, with more humid, shady, cool mountain holm-oak woodlands than all of the rest of the islands of the archipelago, yet also has flat, arid, hot and shrubby habitats similar to those of Formentera. In summary, the Balearic Islands have a wide range of landscapes, from these humid woods of the northern Mallorcan mountains, to the flat semi-desert of Formentera; and from the natural landscapes of Mallorca and the relict cultural landscapes of Minorca, to the modern crowded urban landscapes of Palma de Mallorca and the big coastal tourist resorts.

Another difference of the Balearics lies in their rapid and intensive development for tourism. As they are closely located to the countries of their European visitors and have abundant facilities, the Balearics are the epitome of Mediterranean sun and beach tourism. Nevertheless, there are differences in tourism development within the Balearic Islands. Mallorca and Ibiza have developed from the onset an intensive sun and beach tourism, whereas this process began later and less intensively in Minorca. The development of tourism in Formentera was coincident with that of Minorca, although with a singular type of tourism: massive numbers of day-visitors from Ibiza in the summer season (Table 12.2).

The tourists must reach Formentera by sea as there is no airport, and airport arrivals (NA) have been substituted in Table 12.2 by arrivals at the port of Savina. Formentera's NA/CL index has increased greatly in recent years, although not comparable to that of Ibiza's, where most tourists remain one or two weeks. Most of those arriving on Formentera only spend the day, and do not need accommodation.

12.2 Physical Environment

In geological times (Upper Miocene), the Balearic Islands were linked to the continent and formed the north-eastern part of the mountain ridge of the southern Iberian Peninsula (the present Baetic System) (Hsu et al. 1973). Calcareous rocks predominate in these structures, except for the northern half of Minorca and some small localized areas in the north of Mallorca, which are formed by non-calcareous paleozoic and Inner Triassic substrates (quartz arenites). Strong karstic processes operate in the zones of calcareous substrate. The caves that result from these processes, such as the spectacular *lapiaz* fields (calcareous forms formed by water dissolution) in the northern half of the Serra de Tramuntana in Mallorca provide important tourist attractions.

Mallorca represents about 75% of the total area of the archipelago, but makes up less than 50% of its total coastline. The coastal typology is very important for tourism-dominated islands like the Balearics, where there are four main coastal types: low sandy coasts, low rocky coasts, high tabular rocky coasts (called 'marinas') and high structural rocky coasts (the Tramuntana and Llevant mountain ranges). The first type is usually linked to beaches, coastal sand dune systems, brackish areas and coastal lagoons, all of which are suitable for mass (sun and beach) tourism development. Formentera has the highest proportion of this coastal type, with half of its coast made up of these formations. However, for this island, the second type is not frequent. The high tabular rocky coast is formed by extensive high plains, or mesetas, with the weathered edges tumbling out into the sea, exposing vertical cliff faces. It has received the name 'tabular' (from the Latin: tabula = table) due to its resemblance to a table. This coastal type is dominant on the southern coast of Mallorca and Minorca and in Formentera (forming approximately the other 50% of the coast). Finally, the high structural rocky coast has high, steep cliffs formed by the slopes of the mountains closest to the sea ('Costa Brava'). This coastal type is not desirable for sun and beach mass tourism, but it is very attractive for high-end tourism, due to its high level of nature conservation and the magnificent scenic views. It is the dominant type in Ibiza (about 80%) as well as in the half of the northern coast of Mallorca and Minorca, but is not present in Formentera. Mallorca is the only island with a high proportion of structural cliffs rising over 50 m a.s.l. (more than 50% of the high structural rocky coast).

When pollution-free, the coastal waters in the Balearics are very transparent, with 10% of surface light still visible at 20 m depth. Marine phanerogams and photophilic algae are found down to 40 m depth, and in the circumlittoral area, where light penetration supports plant life, they occur at 150 m depth. The Atlantic marine currents enter from the south and invade the channels between islands, while the Mediterranean currents, coming from the Gulf of Lyon, reach the north-west coast and also enter these same channels, creating an interplay with Mediterranean waters dominating in the winter and Atlantic ones in the summer (Morey and Martínez-Taberner 2000).

The Balearic climate is marine Mediterranean. Mean annual temperature varies along two gradients, a latitudinal one increasing from Minorca in the north-east to Ibiza and Formentera in the south-west; and an altitudinal one, increasing from 10 °C of the highest mountains of the Mallorcan Mountain Ridge 'Serra de Tramuntana' to the 17 °C of Formentera. Precipitation is mainly linked to altitude, from the high annual precipitation of the Mallorcan Serra de Tramuntana with more than 1,000 mm/year, to the scarce precipitation of Formentera with less than 300 mm/year. Both factors (temperature and precipitation) produce a strong aridity

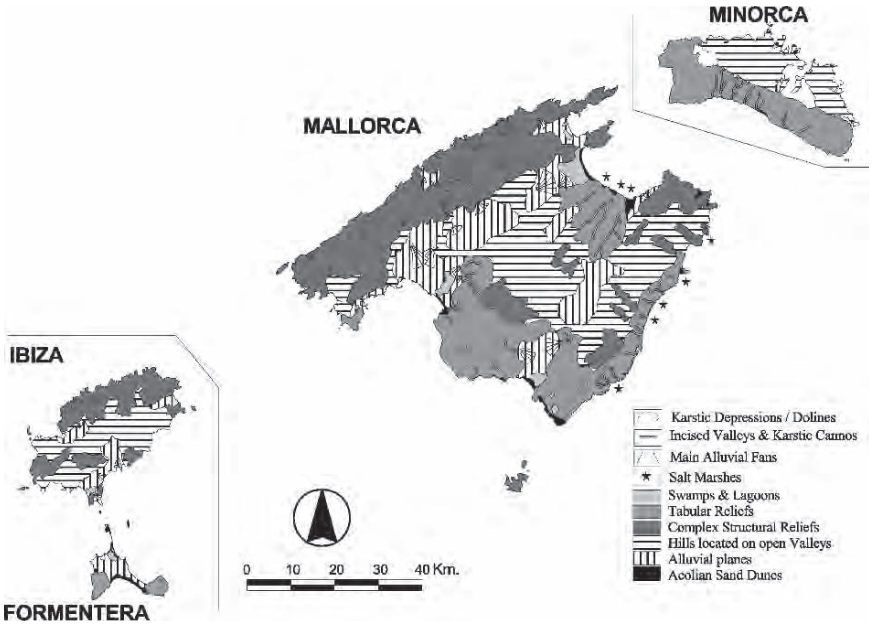

Fig. 12.2 Geomorphologic units of the Balearics Islands

gradient, ranging from the humid Serra de Tramuntana summits to the subdesertic Formentera, producing a great diversity of terrestrial communities and ecosystems. As well as the local pattern of coastal breezes, there are important cold strong winter winds from north-west and north, affecting the 'climate comfort'. All of the Balearic Islands have Mediterranean-type intermittent rivers (torrents), often ephemeral, with run-off occurring only after a rainstorm, and usually during autumn and winter. There are no natural freshwater lakes or lagoons in the Balearics, but there are some brackish saline and hypersaline coastal lagoons, referred to locally as 'albuferas' and 'estanys'. All these geological and climatic processes have shaped the physical landscape of the Balearics in the geomorphological units shown in Fig. 12.2.

The complex structural reliefs, formed by the Hercynian folding, are only present in Mallorca and Ibiza. They form steep mountain ridges or isolated mountains. When they border with the sea, they form the high structural rocky coast type, with beautiful scenic views. The coastal 'tabular' reliefs, forming the high plains or 'mesetas', are especially developed in Minorca, where they occupy the 'Migjorn Region' (South and West). They are also well developed in Mallorca and Formentera, but they are not present in Ibiza. They are crossed by intermittent rivers forming gullies ('barrancos') that reach the sea in pleasing coves. The hills with scattered plains and valleys occupy all the northern half of Minorca ('Tramuntana Region'), a great part of the centre and SE of Mallorca and a great part of Ibiza; but they are not present in Formentera. Finally, some alluvial plains are present in Mallorca, Ibiza and Formentera, but they are not important at all in Minorca, and are usually linked to the brackish areas and albuferas.

The soils of the Balearic Islands are intensely influenced by climate. They have a high percentage of carbonates with little horizon development and a low organic content. The best cultivated lands are located in the potential domain of the holm oak. These areas have been occupied by agricultural activities stemming from ancient times which replaced the original oak forests. Although some of the forested areas have been preserved over the years for firewood and charcoal, they have suffered a progressive recession in competition with agriculture. Another soil characteristic is that much is anthropic, insofar as a good portion of the topsoil has been traditionally transported from fertile areas to fill the terraced slopes.

Aquifers represent the main hydrological reserves of the Balearics. Aquifer-abstracted water is used for urban consumption, tourist resorts and agriculture. The island of Mallorca presents three basic hydrological units: the Tramuntana Mountain Range, the Pla and the Serres de Llevant. The Serra possesses many small, independent aquifers, while those of the coast suffer from salt water intrusion. The interior waters of the Pla are of good quality and so this aquifer is of great importance, whilst those of Llevant have great compartmentation and can be strongly salinised. The Pityusics also experience problems with salinization, but for Minorca the overall balance is positive.

12.3 Biotic Elements

12.3.1 Flora and Vegetation

As with most small islands, the Balearic biodiversity is lower than that of similar regions of the continent. Nevertheless c.1,600 plant species have been described for the Balearic Islands. The high number of endemics was noted by the first botanical explorations of Balearics during the 18th century. There are a total of 65 endemics, with a density of 13.5 for 1,000 km^2 (Mayol and Machado 1992). After thousands of years of human occupation, most of the Balearic land has been transformed in rural agricultural and urban areas, with the natural vegetation only remaining in places unsuitable for these purposes.

Only a few tree species are present and these form woodlands. They are the holm oak, *Quercus ilex*, the only natural pine tree, *Pinus halepensis*, and the ‘savina’ *Juniperus phoenicea*. Ranked on the basis of sensitivity to aridity, the *Quercus ilex* would be considered the most sensitive, and *Juniperus phoenicea* the most tolerant. The woodlands of the Balearic Islands can be divided into two types, those of the holm oak formed by *Quercus ilex*, and the coniferous woodlands. Extensive holm-oak woodlands are present in the Mountain Ridge Serra de Tramuntana in Mallorca and in the northern half of Minorca (Tramuntana Region), but are not present in the Pityusic sub-archipelago. These types of

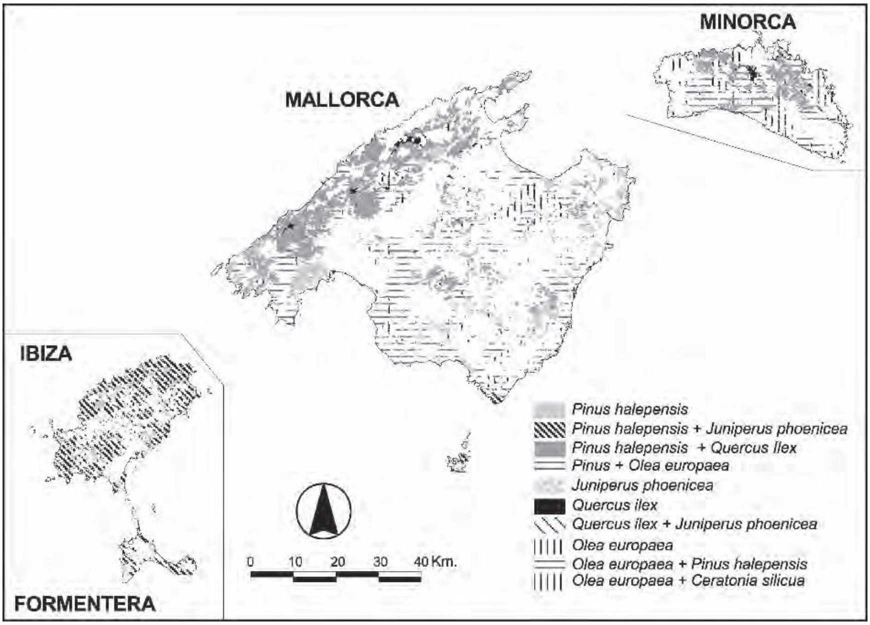

Fig. 12.3 Forest map of the Balearic Islands

woodlands are also distributed by island. In Mallorca and Minorca almost all the coniferous woodlands are formed entirely by pine trees; yet in Ibiza, many of these woodlands are mixed formations of pines and *Juniperus phoenicea*, while in Fomentera *Juniperus* woodlands dominate. This distribution is a consequence of the general aridity gradient of the Balearics. The pine tree is a heliophilous invader species, invading the land after a disturbance (e.g. wild fires, or total or partial felling). Therefore, the mixed oak and pine woodlands are common everywhere throughout the larger islands. Another dominant vegetation type is the 'càrritx'. The carritx (*Ampelodesmos mauritanica*), is a pyrophytic, North African grass, tolerant of arid conditions and able to survive on very poor soils. In many cases, in the Serra de Tramuntana of Mallorca for example, this vegetation type takes over degraded old holm-oak woodlands that have suffered a series of successive and frequent wild fires. According to the Spanish Forest Inventory 1997–2006 (Villanueva Aranguren 2002), eight forest types have been recorded for the Balearic Islands and are shown in Fig. 12.3.

Holm-oak woodlands and *Olea europaea* shrublands are present only in Mallorca and Minorca. The former are present mainly at the Serra de Tramuntana in Mallorca and at the centre of Minorca, while the latter are scattered in both islands. In contrast, almost all the woodlands of the arid islands of Ibiza and Formentera are pine woodlands and mixed pine with *Juniperus phoenicea*.

Most of these areas are suitable for agriculture, but principally the plains and valleys, which are occupied by extensive traditional crops with the natural vegetation is reduced to occupying the hills and mountains or the plains by the sea, lands with soils of low agronomic value. The most common natural plant communities are: holm-oak woodlands, and pine woodlands. The geographical distribution of the main plant communities is linked to the climatic gradients. The holm-oak woodlands are reduced to Minorca, where they are present in scattered woodlands, and to the mountain ridge of the Serra de Tramuntana of northern Mallorca, where the annual precipitation is enough to ensure their survival.

12.3.2 Fauna

The Balearic Fauna is quite rich with an outstanding number of endemics. The main animal groups are shown in Table 12.3. The species diversity and the rarity of some of the marine birds make them the most important avian species in the Balearics. Of important note are Cory's shearwater *Calonectris diomedea*, the Yelkouan shearwater *Puffinus yelkouan*, and the storm petrel *Hydrobates pelagicus*. The shag *Phalacrocorax aristotelis* is a common species. The seagulls and terns are also abundant and of great faunal value, of interest is Audouin's gull *Larus audouinii*, which is considered to be in great danger of extinction.

Birds of prey or raptors like the red kite *Milvus milvus*, are also very frequent species. Perhaps the most representative of the threatened Balearic avian fauna is the cinereous or the European black vulture, *Aegypius monachus*, which inhabits Serra de Tramuntana. Mention should also be made for the peregrine falcon *Falco peregrinus*, Eleonore's falcon *Falco eleonorae*, and the Eurasian Kestrel *Falco tinnuculus*.

Among the endemic animal species of special interest is the small midwife toad, *Alytes muletensis* (local name, 'ferreret'), that inhabits streams at the Mallorcan northern mountains. This is a new species, discovered in the 1980s and provides a good example of an endemic insular species which, in an environment with fewer predators, evolved with the loss of some features that continental species with more enemies must possess for their survival (Hemmer and Alcover 1984). *Alytes muletensis* is similar to the common continental toad, *Alytes obstetricans*, but it is smaller and does not have the glands which produce a repulsive smell (Hemmer and Alcover 1984).

Diversity is especially low for terrestrial vertebrates, mainly as a consequence of isolation, but is also due to the impacts of human activities and invasive species. The first type of impact, human intervention, has occurred since the colonization of the islands by humans. For example, it is considered probable that the largest terrestrial vertebrate living in Balearics until about 4,000 years ago, the endemic goat species *Myotragus balearicus*, was exterminated by hunting (Yll et al. 1997).

Table 12.3 Main animal groups in the Balearics

Amphibians	Four amphibian species are present: the Iberia green, or Pérez's frog *Rana perezi*, (found in pools, reservoirs and torrents) the Mediterranean or stripeless tree frog *Hyla meridionalis*, (Minorca), the European green or variable toad *Bufo viridis* (a rare species), and of special mention, the Mallorcan midwife toad, *Alytes muletensis*, (a Balearic faunal gem)
Reptiles	15 reptile species, including tortoises, turtles, lizards, and snakes. Of note is the frequent presence of the loggerhead sea turtle *Caretta caretta* and the spur-thighed tortoise, tortuga mora *Testudo graeca*
Lizards	Four lacertid species are present: Lilford's wall lizard, *Podarcis lilfordi* (Baleares), the Ibizan wall lizard *Podarcis pityusensis* (only in the Pityussae), the Italian wall lizard, *Podarcis sicula*, and the Moroccan rock lizard *Podarcis perspicillata* (only in Minorca)
Snakes	Three snake species stand out, the false smooth, or hooded snake *Macroprotodon cucullatus* (Mallorca-Minorca), the viperine grass snake *Natrix maura* (Mallorca-Minorca) and the ladder snake *Elaphe scalaris* (only Minorca)
Geckos	The Moorish wall gecko, *Tarentola mauretanica*, and the Turkish gecko *Hemidactylus turcicus*
Marine mammals	12 species of marine mammals can be found three of which are included in the Bern Convention. i.e. the humpback whale *Megaptera novaeangliae*, the common delphin *Delphinus delphis*, the bottlenose dolphin *Tursiops truncatus*, the fin whale *Balaenoptera physalus* and the sperm whale *Physeter macrocephalus*
Terrestrial mammals	14 terrestrial mammals, of which only the rabbit and the hare are not protected. A special mention should be given to the small carnivores introduced by the Arabs for rat control: the genet *Genetta genetta* (Mallorca-Minorca), the European pine marten *Martes martes* and the least weasel *Mustela nivalis*
	There are three species of insectivores: the North African or Algerian hedgehog *Atelerix algirus* and the greater white-toothed and the lesser white toothed shrew species *Crocidura russula* and *Crocidura suaveolens*, respectively
Bats	13 bat species, all of them protected by law. These are divided by two dwelling types: the cave dwelling bats such as *Rhinolophus ferrum-equinum, Miniopterus schreibersi, Myotys myotis* and the fissure dwelling bats, such as *Tadarida teniotis, Eptesicus serotinus, Plecotus austriacus*

12.4 Cultural Landscapes

The Balearic landscapes have been strongly influenced by the impacts of the many peoples who have inhabited the islands. Four main periods are evident: (1) from c.2000 to 400 BC: the prehistoric inhabitants, (2) from 400 BC to 1229: the historic people from the Greeks and Phoenicians to the different Arabic peoples, until the conquest by James I of Aragon, (3) from 1229 to 1960: Balearics as a kingdom of the Crown of Aragon, and later as a province of Spain (4) since 1960: the mass tourism development with a decentralization of the national administrative processes.

The main impact of the first inhabitants on the Balearic landscape was produced by the use of fire, which increased the frequency of fires beyond the rate of natural occurrence. In addition to fire, hunting led to the extinction of the only endemic bovid in the islands, *Myotragus balearicus*, leading to changes on the natural vegetation. During the Bronze Age, megalithic monuments were constructed that remain important landscape elements in Minorca and Mallorca. The main impacts of the second period are the beginning of agriculture and the start of an administrative system with the foundation of towns like Palma de Mallorca by the Romans and Ibiza by the Phoenicians. Important cultural landscape elements of this period are defensive buildings such as castles and the creation of fortified cities, e.g. Palma de Mallorca, Alcudia, Ciudadeki and Ibiza. In the third period, the archipelago's conquerors restructured the administration of each island, which has remained basically the same up to the present day. The islands remained isolated from the continent, with agriculture and maritime commerce as their main economic sources, and no important changes affecting landscape were made, apart from those produced by the British domination in Minorca in the 18th century. There are important monuments from this long period, for example the Cathedral, the 'Lonja' and the Castle of Bellver at Palma de Mallorca. Finally, in the last 50 years tourism development has produced substantial and rapid changes affecting the islands' landscapes. The islands are no longer isolated, and their number of inhabitants has greatly increased; the intensive social, economic and cultural development has had major repercussions on the natural and cultural landscapes.

Despite the increasing tourist pressure, some highly valued ancient cultural Balearic landscapes persist (Table 12.4; Morey 1994, 2001).

Most of these cultural landscapes are related to traditional agriculture and farming (Type 1 to 11). The Minorcan pastures for cows and sheep (Type 1) differ entirely from the other Balearic landscapes. This landscape originated from English domination in the 18th century and still resembles some English landscapes (Fig. 12.4). It supports some prosperous Minorcan industries based on dairy products and its sustainment depends on their economic profit. Other interesting landscapes (Type 6) include the extensive terraced fields of olives intercropped with other cultivated plants in the rocky, limestone mountains of the north-west of Mallorca, in the 'Serra de Tramuntana'. They are remarkable for their steepness and consequent high proportion of stone walls to field area (Fig. 12.5). They were abandoned at the beginning of tourism development and are at present threatened landscapes. A singular landscape type for all of the Mediterranean is that of the forage-crop fields at the plain east of Palma (Type 10), where, until the beginning of tourism development, a forest of windmills pumped irrigation water to the forage-crop fields and cattle of the smallholdings. This landscape was formed during the 19th century when the surrounding brackish areas were drained and the water pumped off by these windmills, making the land suitable for use for irrigated crops. At present, the land is threatened by salinization once again, although this time it is the groundwater, as the aquifer has been overextracted for tourist uses and windmill use has been

Table 12.4 Main cultural landscape types in the Balearic Islands (in increasing level of alteration)

Type	Main land use or occupation	Distinguishing features	Islands where present*	Cultural value	Environmental status*
1	Dry farmed crops	On plains and/or hilly land, with villages	Mi	VH	T
2	Dry farmed crops	On plains and/or hilly land with trees and villages	Ma	H	VT
3	Dry farmed crops	On plains and/or hilly land scattered country houses	I	H	VT
4	Dry farmed crops	On plains and/or hilly land without trees and with villages	Mi	L	T
5	Dry farmed crops	On plains and/or hilly land, with scattered country houses	F	H	T
6	Dry farmed crops	On steep slopes (terraces) with villages	Ma	VH	VT
7	Dry farmed crops	On steep slopes (terraces) with scattered houses	I	H	T
8	Large farms 'possessions'	Mainly agriculture plus cattle	Ma	VH	VT
9	Large farms 'llocs'	Mainly pasture for sheep and cattle	Mi	VH	T
10	Irrigated crops	Crops with windmills	Ma	VH	VT
11	Irrigated crops	Without wind mills	Ma	L	T
			I	L	VT
12	Salt pans		Ma	H	T
			Mi	L	T
			I	VH	NT
			F	VH	NT
13	Traditional villages for summer leisure		Ma	VH	VT
14	Small fishing harbours		Ma	VH	VT
			Mi		
			F		

*Ma: Mallorca; Mi: Minorca; I: Ibiza; F: Formentera; VT: very threatened; T: threatened; NT: not threatened; VH: very high environmental value; H: high environmental value; L: low environmental value. (Environmental Value refers only to cultural value.)

substituted by modern electrical water pumps. This has resulted in the abandonment of this beautiful landscape and currently only a few fully operational cloth or metal-sailed windmills persist.

Of the industrial landscapes, those of the saltpans (Marin et al. 1994) are of particular interest (Type 12). At present, only two saltworks in Mallorca and one in Ibiza are in operation, while those of Formentera were abandoned around 1980.

Fig. 12.4 Minorcan pastures: reminders of English domination in the 18th century (*See Colour Plates*)

Fig. 12.5 Terraces on the Tramuntana Mountain Range (*See Colour Plates*)

The present Balearic landscape is a mix of natural and ancient cultural relict landscapes, and many modern urban-tourist landscapes, mainly in the coastal areas. A new hierarchical classification of the landscapes of Spain has been edited (Mata and Sanz 2003) describing and mapping 1,263 Landscape Units, grouped in 116 Landscape Types, forming 34 Associations of Landscape Types. The Balearics, with only about one percent of the Spanish area, include 41 Landscape Units (3.2%), 8 Landscape Types (6.9%), and 4 Associations of Landscape Types (11.7%). As in most Mediterranean Islands, the landscape diversity is much higher than the mean value for the continent at any hierarchical level.

12.5 Recent Environmental Changes

Like the rest of Spain, the Balearic Islands bore the consequences of the Spanish Civil War (1936–1939) and World War II (1941–1944), which left them under a centralist structured political system different from the rest of Western Europe and under the command of General Franco, and this situation produced political and economic isolation. Therefore, until the beginning of tourism development (in the late 1950s), the Balearic people maintained their traditional genres de vie, mainly agricultural based, and thus conserved their traditional rural landscapes.

Until tourism arrived the main changes induced by humans, have been due to hunting and overexploitation Development of mass tourism has lead to the most important and intensive environmental, social, economic and cultural changes in Balearics since the Conquest by James I of Aragon in 1229. All the social and economic indices, i.e. annual number of visitors, population density, annual economic income, social status, grew explosively and thus changed completely the existing Balearic way of life.

Taking the number of airport arrivals as an indicator of tourism growth, Morey (2003) compared the pattern of tourism development in the Balearics with that of a population increase that occurs when a new animal species reaches a new suitable non-occupied area. This pattern is shown in Fig. 12.6.

This pattern in the increment of mass tourism differs from the two classic sigmoidal curves of the pioneer animal populations: the logistic or sigmoidal and the

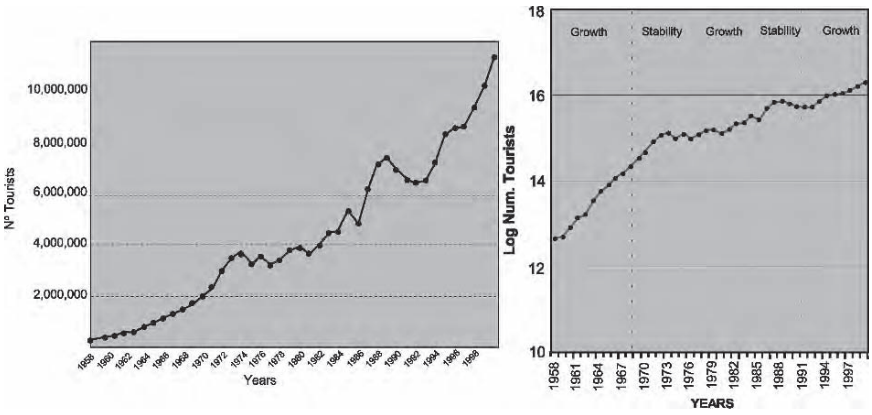

Fig. 12.6 Tourism evolution since 1958

exponential curves (usually with alternate exponential increasing and quickly decreasing periods). Instead, the tourism increase in the Balearics has two periods of exponential growth, separated by three periods of stability. The time of duplication of the number of tourists per year at the successive periods of growth increase are 4, 5, 8 and 9.5 years. The periods of instability, which imply economic crisis and social troubles, can be produced either by changes originating outside the areas of influence of the tourism sector. The case of the first crisis, which was sparked by the worldwide shortage of petroleum, or by changes within the tourism area, which was the case of the second crisis, which was triggered by the degradation of the natural environment and the landscape of the tourist areas and surroundings, plus an increase in awareness by tourists. Therefore, the pattern of growth in tourism may be interpreted as a series of successive adjustments (action–reaction) amongst the components of the tourist-environmental system (Morey 2003).

The main impacts of the long and intensive first period of tourism growth (13 years) on the Balearic landscape affected the coastal landscapes, especially those of the sandy coast: beaches, sand dunes, littoral systems, and brackish areas that became partially or totally occupied by hotels and other tourism infrastructure. The new beach hotels produced a 'wall of concrete', bisecting the coastal landscape into a narrow coastal area and an inland coastal area with a resulting loss of their coastal characteristics of these resultant areas. This type of tourist development was labeled with the pejorative name of 'balearisation'. Coastal waters and coastal ecosystems also suffered, as well as the benthic meadows of *Posidonia*, affected by sewage pollution. The people and authorities of the Balearics were aware of this environmental degradation, but most believed that the great social and economic improvements compensated for this destruction (Morey, 2004).

The first period of stabilization sounded the alarm against the fast and uncontrolled tourist growth. Two successive laws were passed to control the tourism growth, and the first local ecological associations were created. The first important actions for improving the environment were thus adopted. The second period of tourist growth began at the end of the first worldwide oil crisis, while the second period of stabilization was produced by a crisis in the British tourism industry. Finally, the third period of growth was initiated by the abandonment of Balkan and North African mass tourism destinations, owing to civil war and terrorism, respectively.

The main impacts of tourism on the environment are summarized in Table 12.5. Most of these act synergistically, producing strong negative impacts on the landscape, especially on the cultural value of landscapes, as shown in Table 12.4. In summary, these impacts affected the coastal areas through occupation and overexploitation, and the inland areas, mainly the agricultural zones, through abandonment.

The result of the mass tourism development in the Balearics can be described as a total change of the occupation, utilization, perception and appreciation of the island territory. The evaluation of the territory before tourism development was based on the economic values derived from its capacity for agricultural or industrial uses, but since tourism development a total change in evaluation occurred with the economic value of the territory being based on its capacity for mass tourism. The best places for mass tourism development are the coastal areas, mainly with

Table 12.5 Human pressures on the Balearic Islands

Pressure	Expression
Land consumption	Mainly expressed by urbanization
Water-related problems	High consumption of drinking water and water for irrigation, spatially concentrated in touristic and rural areas, and temporarily in the summer season. There are also problems related to the high demand for waste water processing, salinization, and contamination
Destruction of natural areas	Development and tourism activities
Quarries	Open-pit mining operations present an important landscape impact
Pollution	Production of urban solid residues
City-planning impacts	Development, subdivision of rural and wildland
Recreational pressure	
Air and noise pollution	
Energy consumption	
Erosion & Desertification	Erosion risks are elevated in the areas with high slope which have suffered from forest fires. Soil loss is the direct effect of this process. The Balearic Islands rank third among the other regions in terms of extreme erosion, with 5% of their territory subjected to this process, caused by fire and overexploitation
Floods	Floods have a historical impact in the Balearics. Numerous floods and their patterns have shaped the layout of the historical placement of human settlements and structures
Forest fires	Especially affected Mallorca and Ibiza

extensive sand beaches and dune systems, as well as small coves of the rocky coast, that are fragile and vulnerable natural systems with high ecological and landscape values. Therefore, the territory is valued for its function, not for the products it can produce (agriculture) or it can support (industry), but as the territory per se – its geographical situation – (see Box 12.1) and the added values linked to this, such as tourism and commerce. These areas were partially occupied by tourist resorts, with strong degradation of their natural ecological values. The increasing appreciation of the ecological values, thanks to the influence of conservationist thinking, has produced a conflict between the conservation of these territories, being submitted to a conservation legal status, and their occupation by tourist resorts (Seguí 1995).

Until the arrival of mass tourism, the Balearic value system did not positively evaluate the coast: it was neither a recreational space, nor an agricultural space (not very productive) nor a habitable space due to the close lying swamps with malaria-bearing mosquitoes. Only a few coastal areas were developed before mass tourism, notably the Port of Pollença and Formentor. Only with the arrival of the tourists, the modern-day, summertime use of the coastal spaces for swimming, sunbathing, and other leisure activities began. This set a precedent, as for the first time for the islands' societies, natural spaces were considered as recreational areas and not just for work and production.

Tourism has changed the evaluation of insularity. Before tourism the concept of insularity was negative, as it produced many inconveniences: geographical isolation, trade difficulties, etc., with very few advantages, which was reflected in the economic attainment of the islands. With mass tourism, insularity became a positive trait, with

Box 12.1 Landscape Analysis of Mallorca

The Balearic Islands University and companies MECSA-IDOM conducted an environmental assessment of Mallorca in 2004 to provide a foundation for the Urban Insular Planning Plan by the Consell de Mallorca. The variables mapped were lithology, hydrology, territorial risks, vegetation, fauna, ecosystems, infrastructure, etc. A landscape evaluation was produced as a tool for urban planning and to pinpoint areas with the highest landscape value. Instead of adopting landscape ecology indicators in favour of a simpler but more comprehensive model based on multicriteria, experts from diverse fields cooperated to generate landscape cartographic representation (Fig. 12.7) based on GIS using raster landscape value and vectorial landscape units.

Methodology

Raster landscape value: The territory is divided into units/cells 100 × 100 m, each one acquires a landscape value depending on its landscape variable/attributes.

Vector landscape units: Large landscape units are identified plus a valuation of aesthetic interest in each. An Integrated Landscape Value map requires an overlay of the two. The selection of variables was determined via a Delphi Survey of 20 professionals to evaluate the role of territorial variables and their relative aesthetic importance and to provide approaches for the identification of landscape units/sub-units and their relative aesthetic importance.

For Mallorca the following characteristics were deemed important: (1) land use, (2) topography, (3) distance to coast, (4) distance to urban areas/main roads and (5) stream presence. Weightings were assigned to each variable depending on its importance to produce the Raster map of Landscape value of Fig. 12.8.

Note the high landscape values in the coastal zone with pronounced slope, low human influence and a natural vegetation cover. Medium landscape values occur adjacent to the littoral, have sparse natural vegetation, low slope and little human influence. Low landscape values occur in the interior with little topography and strong human influence. The Vector map (Fig. 12.9) shows nine relatively homogeneous units, with sub-units distinguished by particular features. The overall Landscape Value map, obtained by integrating the vectorial landscape units and the raster landscape values give an interesting assessment of landscape shown in Fig. 12.10. This shows maximum valuation of the Tramuntana Mountains, north coast of Peninsula d'Arta and the south Mallorcan coast. Medium landscape areas include the flat Pla de Raiguer dominated by agriculture/vegetation, and the low landscape values are adjacent to large urban areas.

Balearic protected areas are scattered with problems for connectivity and metapopulations. In this context the creation of protected corridors (ecological networks) is proposed. For urban areas e.g. Palma a 'blue green conservation ring', to include the marine ecosystems of the Bay of Palma and the Tramuntana Mountains to the east, is a possibility. Around the tourist resorts of Mallorca's north coast there is a need for a 'green conservation' belt to link mountain areas.

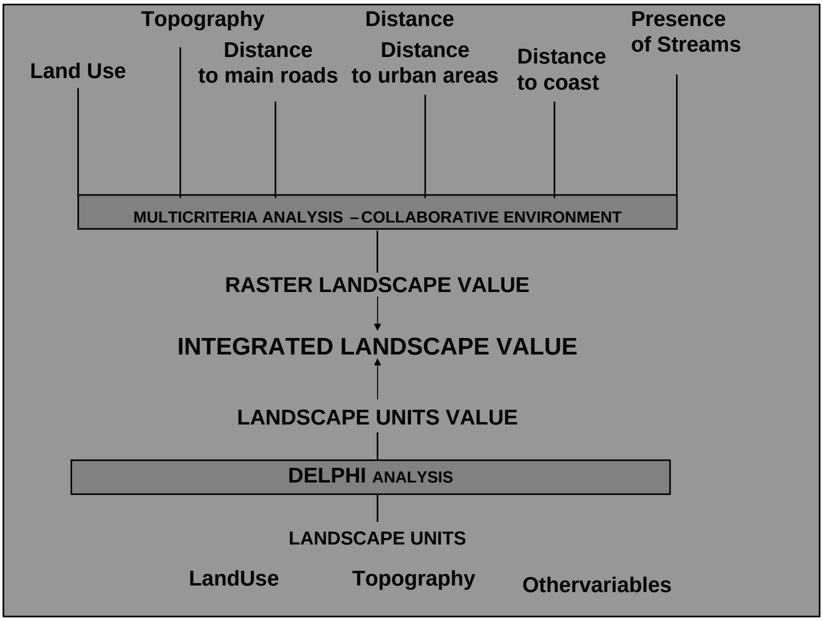

Fig. 12.7 Landscape Analysis methodology

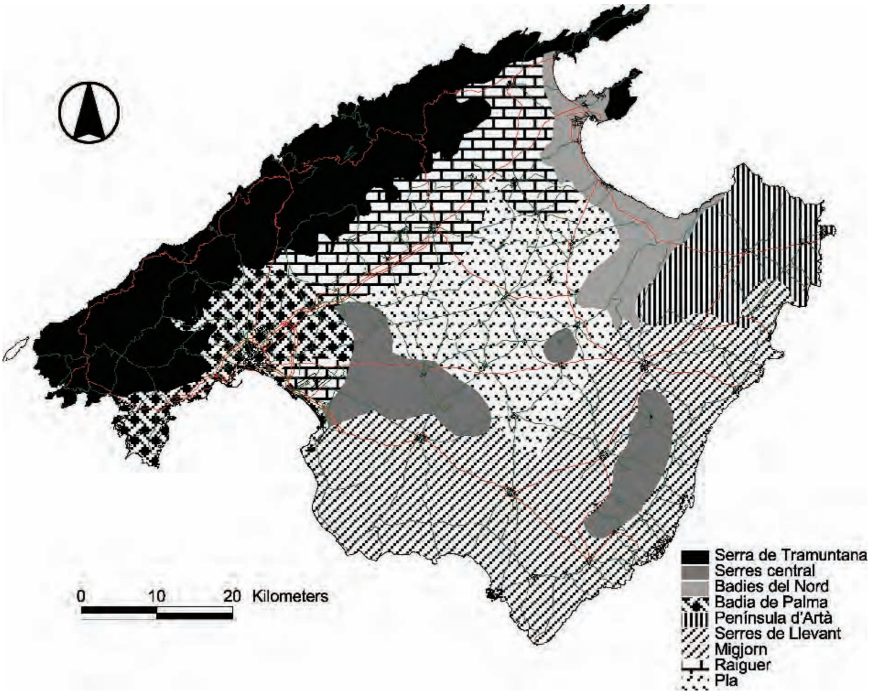

Fig. 12.8 Raster map of Landscape Value

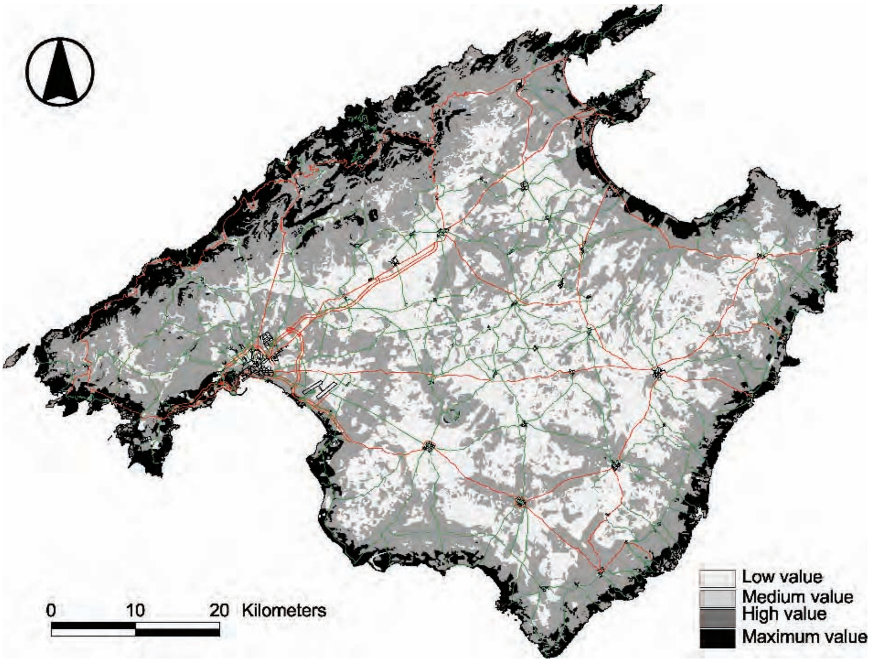

Fig. 12.9 Vector Map of Landscape Units

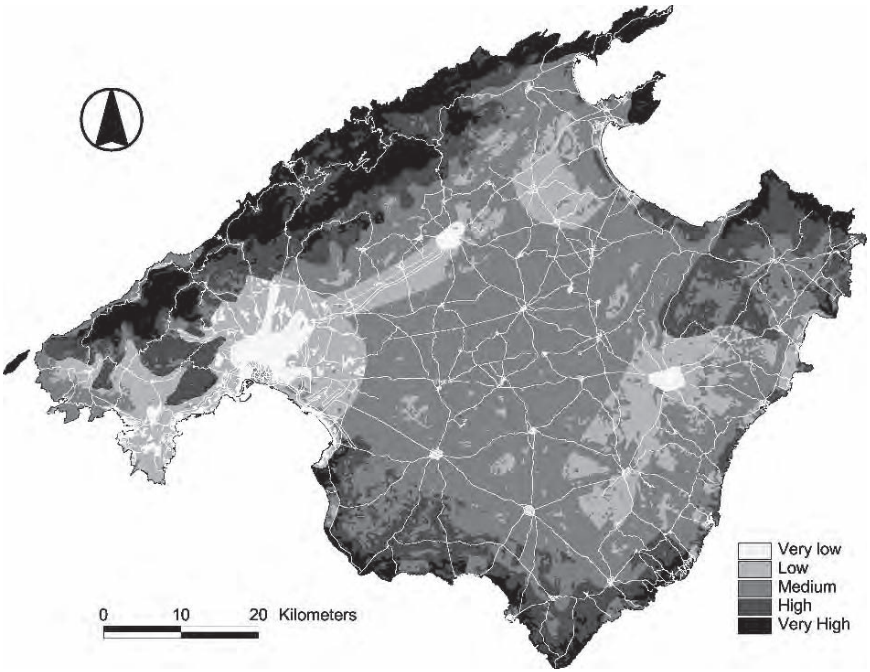

Fig. 12.10 Final Landscape Value

many advantages, including the improvement of communications. The Palma Airport is one of the Spanish airports with better national and international communications (mainly with the rest of Europe) with few inconveniences, all of which has translated into a great increase in the wealth and the standard of living of the islands.

From a global point of view, two island types can be differentiated in the Balearics: the first formed by Mallorca and Ibiza, and the second by Minorca and Formentera. The main traits of the first group of islands are as follows. These are mountainous islands, with mountain ridges in the north-west, which protect the rest of the island from the cold winter winds, and provide the lowlands with a mild and comfortable winter climate. Due to this wind protection, traditional dry extensive agriculture consists of annual cereal crops with scattered fruit trees and post-cereal-harvest cattle grazing, practices amenable to the savanna and 'dehesa' ecosystems. Traditionally, most of the population is concentrated in primary settlements (Palma in Mallorca and the City of Ibiza in Ibiza), popularly known as *Ciutat* in Mallorca and *Vila* in Ibiza. These cities polarize the economic, social and cultural life. Tourism development was accepted since the beginning, as people were unaware of the possible negative impacts of tourism on the natural and cultural environment.

In contrast, the second type of islands are flat and windy, with cold winters, especially Minorca. Due to the strong winter winds, there are no trees intercalated with the traditional extensive agriculture, made up of pastures in Minorca and cereals in Formentera. Their population is distributed into settlements of more or less equal density and importance, with the island's economic, social and cultural life being focused in more than one settlement. Mass tourism development for the second group began some years after that of the first group of islands, and it was never as intensive as that of Mallorca and Ibiza, + because the population of these two islands, has been aware of the possible negative impacts of tourism on the natural and cultural environment since the beginning of tourism development (Morey 1989). Due to the great biodiversity of the Balearics and its extreme structural and functional fragility, any type of environmental impact is greatly magnified.

12.6 Landscape Conservation

Although there are many legal instruments for environmental protection in the Balearic Islands, in practice there is an overlapping of laws and jurisdictions on the subject to be protected. In terms of landscape conservation, these overlaps render this protection as a whole highly ineffective. The process of political decentralisation that has concurred with the beginning of tourism development has produced many difficulties for environmental conservation. In the 1960s the centre of environmental decisions was the state (Spain). With the onset of the Spanish political change that divided the country into 17 Autonomous Communities, the decision centre was passed to each Autonomous Community and, in the case of Balearics, due to its particular division into islands, the decision centre finally passed to the island governments – or Island 'Consells, – of Mallorca, Minorca and Ibiza-Formentera.

Table 12.6 Legislation and UNESCO declarations related to landscape protection in the Balearic Islands

Protection instrument	Protection Level
Urbanism Provincial Plan (1979)	Regional Government
Law of Coastal Areas (1988)	National Government
Law of Land Planning of the Balearics (1987)	Regional Government
Law for the Protection of the Balearics Natural Regions (LEN) (1991)	Regional Government
Guidelines for Land Planning (1999)	Regional Government
Law for the Conservation of Natural Spaces and Wildlife (1989)	National Government
– National Parc of Archipelago of Cabrera (1991)	
Urbanism Insular Plans (2000 –)	Island Government 'Consell Insular'
Sectorial Plans (Roads, Transport)	Regional Government
Ordination Planning of Natural Resources	Regional Government
– Natural Parc of s'Albufera of Mallorca (1998)	
– Natural Parc of s'Albufera des Grau	
– Natural Parc of s'Albufereta of Pollença	
– Natural Parc of sa Dragonera	
– Natural Parc of Mondragó	
– Natural Parc of Península de LLevant	
– Natural Parc of Ses Salines d'Eivissa i Formentera	
– Natural Parc of Cala d'Hort, Cap Llentrisca, sa Talaia	
Law of Environmental Impact Assessment (1986)	National Government Regional Government
Biosphere Reserve Minorca (1993) Dalt Vila of the city of Ibiza Puig des Molins Prairies of Posidonia of Ses Salines of Ibiza	UNESCO
Directive 92/43/CE, of 21 May 1992, relating to the conservation of natural habitats and wild fauna and flora Royal Decree 1997/1995, of 7 December, which transposes	European Union

The Municipality also plays an important role in environmental protection and landscape conservation. As a consequence, the environmental decisions for the coastal areas depend mainly on the national administration, while only a few competences depend on the Autonomous Government of Balearics, with most of these jurisdictions of the Island Consells, and the rest falling upon the Municipalities.

In the midst of this process of political-administrative changes, especially since the 1970s, a great effort was made to achieve a landscape and natural resources protection by the development of legal issues for conservation (Table 12.6). Examples include the Plan Provincial de Baleares (Provincial Plan, 1978), Ley de Costas 22/1988 (Law of the Spanish coastal Area), Ley de Ordenación del Territorio de las Islas Baleares (8/1987) (Law of Land Planning of the Balearic Islands), Ley para la protección de Espacios Naturales de Baleares (known as LEN)

(1/1984–1/1991) (Law for the Protection of the Balearics Natural Regions), Directrices para la Ordenación del Territorio de Baleares (known as DOT) (6/1999) (Guidelines for Land Planning), as well as Insular Plans, Sectional Plans, Plans of Ordination of Natural Resources, etc. It is also interesting to note, that the Autonomous Government of the Balearic Islands, was the first one in Spain in making a law in 1986 on 'Environmental Impact Assessment'.

Despite this, the Balearic territory continues to be strongly threatened. As Mayol and Machado (1992) point out, this practice of planning has been restricted to 'city-planning' and it has been generally ignored in rural areas.

With regard to the protection of the landscape, three laws dominate: the Law for the Protection of the Balearics Natural Regions (LEN), the Law for the Conservation of the Natural Spaces and Wildlife (flora and fauna) and the Guidelines for Land Planning (DOT). According to the Law for the Protection of the Balearics Natural Regions (LEN), mainly based on a project directed by Morey (1987), about 30% of the Balearic land was designed as an 'Area Natural de Especial Interés' (ANEI) (Natural Area of Special Interest) or 'Area Rural de Interés Paisatgístico' (ARIP) (Rural Area of Scenic Interest). The main difference between them is, as indicated by their official name, the proportion of natural or rural land. This was the first time that the rural areas (ARIP) were subjected to environmental protection in the Balearics, due to their landscape values. The law proposed to develop some type of conservation management for each of these areas, but it was not realistic, and in practice the environmental protection consists only if avoiding possible tourist development.

The Guidelines for Land Planning (DOT) are a set of guidelines for the protection of environmental quality, landscape, biodiversity and historical heritage. Likewise, the DOT establishes the protection of rural and natural areas placing them into the following categories;

- Natural areas of special interest of high-level protection: Promoting the conservation, research and improvement of natural resources;
- Natural areas of special interest: Traditional promotion of activities and conservation of those necessary resources;
- Rural areas of scenic interest: Promotion and improvement of scenic areas and landscapes;
- Areas for risk prevention: A conditioning of the territory from the natural risks (fires, floods, landslides, erosion);
- Areas of territorial protection.

The Ley de Conservación de Espacios Naturales y Vida Silvestre (flora y fauna) (4/1989) (Law for the Conservation of the Natural Spaces and Wildlife) recognizes the right of the natural systems and wild species to survive human activity, and grants the society and the administration the responsibility for administration of the habitats, flora and fauna while establishing assessment mechanisms for monitoring and control of the natural resources. Article 2 of this law points out the objectives: the preservation of the variety, singularity and beauty of the natural ecosystems and landscapes. This law establishes that the competent public administrations will plan the natural resources by means of the 'Plan for the management of the Natural Resources'.

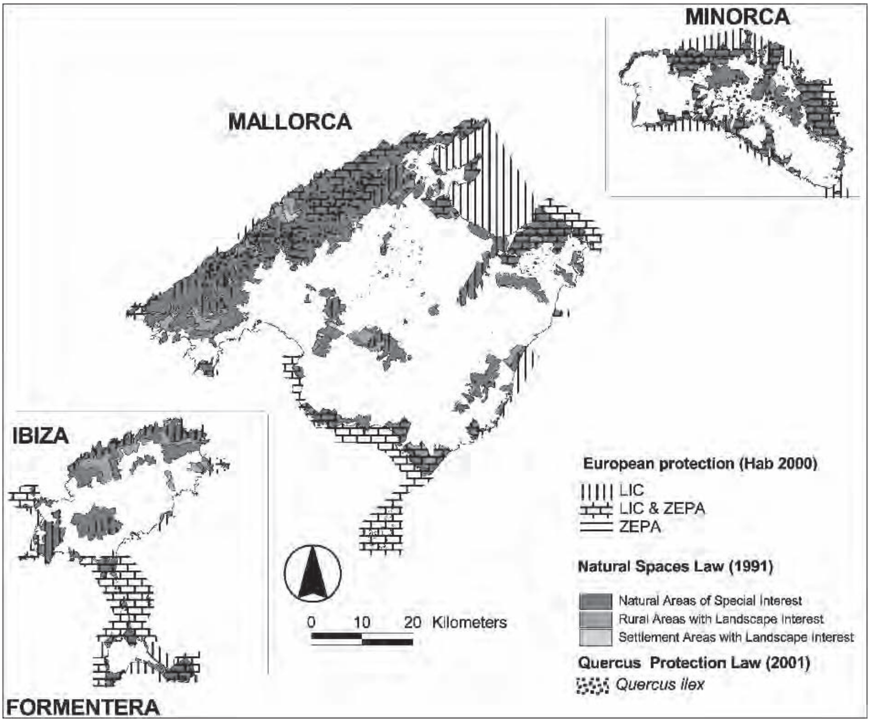

Fig. 12.11 Protected areas at the Balearic Islands (After Mata Olmo and Sanz Herráiz 2003)

Also of great importance is the juridical initiative, developed in 2002 by the Balearic Government, Bill for the Conservation of the Biodiversity for the Balearic Islands. This Law enlarged the concept of a protected landscape and it incorporated into the landscape inventory items such as communal immaterial goods to assist the autonomous law of heritage. Due to political reasons, this bill has not been approved. At present, about 40% of the territory of the Balearic Islands is under some type of legal environmental protection (Fig. 12.11), but most of this is formed by ANEIs and ARIPs, which have a low level of environmental protection.

At present, there are in the Balearics one National Park, one Biosphere Reserve, some Natural Parks and other areas with some type of legal environmental protection. National Park of the Archipelago of Cabrera created in 1991, is the only marine-terrestrial National Park in Spain. This park is consists of an archipelago of small dimensions located to the south of Mallorca. The protected total area is of 10,021 ha, of which, 1,318 are terrestrial and the rest are the surrounding coastline and waters. The Cabrera Archipelago can be considered a continuation of the south-eastern Serra of the Llevant of Mallorca, with a inaccessible and irregular coast. In this area a total of 450 vascular plant species (25% of the Balearic flora), and 30 endemics have been recorded (Fernández et al. 1996).

Of important mention is the decision of October of 1993 by UNESCO to declare the island of Minorca as a Biosphere Reserve. This decision was based on the diversity of the island's natural systems in relation to its small size, their wealth of endemic species, a rural landscape in balance with the environment, and a significant historical heritage worthy of conserving.

The Natural Parks of the Balearics have very different environmental values. The Albufera Natural Park, created in 1998 is the first of its kind in the islands. The s'Albufereta de Pollença Natural Park in Mallorca, and the s'Albufera des Grau Natural Park in Minorca, are mainly formed of wetlands, and their main values are linked to wetlands, mainly the aquatic birds that inhabit them or stop along their migratory flightway. The sa Dragonera Natural Park, is an islet, interesting for its marine birds, and the Mondragó Natural Park is a coastal area at the South of Mallorca, with relevant natural and cultural values, and is a good example of traditional Mallorcan agriculture. Finally, there are also the Levant Pensinsula Natural Park, Ses Salines d'Eivissa i Formentera, Cala d'Hort, Cap Llentrisca, Sa Talaia, Ibiza.

In 1999, the fortified enclosure of Dalt Vila of the city of Ibiza, the ancient Phoenician town of sa Caleta, the necropolis of the Puig, the Puig des Molins and the sea grass prairies of *Posidonia* of the Natural Park of ses Salines of Ibiza were also declared World Heritage site by the UNESCO.

The European directives for birds and habitats protection (Council of Europe 1979, 1992) are also important for landscape conservation and the conservation natural habitats and wild fauna and flora. In the Balearic Islands there are 127 Special Areas for Conservation (SACs) and 50 SPAs (Special Protection Areas).

There is no existing specific legal status for landscape protection in the modern sense of 'cultural landscapes', as promoted by IUCN (Lucas 1982, Green and Vos 2001), despite the fact that most of them are threatened, and with some almost having disappeared (Table 12.4). When the word landscape is included among the objectives of protection, it is usually in the sense of scenic views, not in the modern sense proposed by Landscape Ecology theory (Forman and Godron 1986).

The cultural landscapes listed in Table 12.4 could be used as a basis for organizing landscape conservation, as they have great ecological value. This may be associated with spatial heterogeneity, biodiversity, endemic and threatened species, endangered crop cultivars and cattle breeds, high aesthetic and recreation value, and high cultural values. For centuries, these landscapes have been sustainable, but are now seriously threatened by tourism development (Morey 1987). It is reasonable to assume that similar studies in other regions of the Mediterranean would reveal a comparably rich, yet endangered landscape heritage.

The ancient rural Balearic landscapes satisfy the fundamental conditions for inclusion in the List of Endangered Valued Landscapes (Lucas 1992). These conditions include:

- Sustainability, having been actively used for centuries
- High diversity, comprising spatial heterogeneity, plant and animal diversity (biodiversity), and genetic diversity

- Aesthetic and scenic value, *recreation value
- Ethnic and cultural value (e.g. conservation of rural traditions)

These landscapes are seriously threatened by tourism development, and their conservation is important and urgent.

The impact of tourism on the coastal environment, especially in relation to its geomorphological features has been reviewed by Wong (1993). For conservation aims, the distinction between two island types with respect to tourism development is useful for practical purposes. In the islands of the first type, Mallorca and Ibiza, one of the main problems that need to be faced when developing environmental conservation policies would be to avoid surpassing the island's carrying capacity. Therefore, when the island has reached a high level of human density, there is a greater environmental degradation, which affects the natural and cultural environment, and which consequently results in a decrease in the quality of tourism. In the islands of the second type, Minorca and Formentera, with controlled mass tourism, the natural and cultural environment is also threatened, because tourism leads to the abandonment of traditional activities and uses, such as agriculture, silviculture, hunting and fishing.

References

Brigand, L. (1991) Les îles en Méditerranée: Enjeux et perspectives. Economica – PlanBleu.

Council of Europe (1979) Council directive 79/409/EEC of 2 April 1979 on the conservation of wild birds. Official Journal of the European Communities L 103: 1–18.

Council of Europe (1992) Council directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. Official Journal of the European Communities L 206: 7–50.

Fernández, J. and Pradas Regel, R. (1996) Los Parques Nacionales Españoles. Colección Parques Nacionales. Ed. Organismo Autónomo – Parques Nacionales. Madrid, pp. 482.

Forman, R.T.T. and Godron, M. (1986) Landscape Ecology. Wiley: New York.

Green, B. and Vos, W. (eds.) (2001) Threatened landscapes. Conserving Cultural Environments. Spon Press: London.

Grove, A.T. and Rackham, O. (2001) The nature of the Mediterranean Europe. An Ecological History. Yale University Press: New Haven, CT, 384 pp.

Hemmer, H. and Alcover, J.A. (1984) Història biològica del ferreret (Life history of the Mallorcan midwife toad), Ed. Moll, Palma de Mallorca (Spain).

Hsu, K.J., Ryan, W.B.F. and Cita, M.B. (1973) Late Miocene desiccation of the Mediterranean. Nature 242(5395): 240–244.

Lucas, P.H.C. (1992) Protected Landscapes: A Guide for Policy-makers. Chapman & Hall: London.

Marín, C., Luengo, A., Morey, M. and Hernández, E. (1994) El Jardín de la Sal. UNESCO-MAB, Ecotopía Eds., Santa Cruz de Tenerife (Spain), 247 pp.

Mata Olmo, R. and Sanz Herráiz, C. (eds.) (2003) Atlas de los Paisajes de España. Secretaría General Técnica. Ministerio de Medio Ambiente-Universidad Autónoma de Madrid.

Mayol, J. and Machado, A. (1992) Medi Ambient, Ecologia I Turisme a les Illes Baleares., Manuals d'Introducció a la Naturalesa, 10. Ed. Moll. Palma, 127 pp.

Morey, M. (1987) Espacios Naturales de Baleares. Evaluación de 73 áreas para su protección. Govern Balear-INESE, Palma de Mallorca, 208 pp.

Morey, M. (1989) Análisis crítico del desarrollo de las Islas Baleares (España). In: Instituto Nacional de Investigaçao Científica (ed.). O Algarve na Perspectiva da Antropologia Ecológica, Instituto Nacional de Investigaçao Científica, Lisboa, pp. 383–400.

Morey, M. (1994) Ancient Mediterranean cultural landscapes. Landscape Issues 11(1): 13–17.
Morey, M. (2001) Balearic Landscapes. In: B. Green and W. Vos (eds.) Threatened Landscapes. Conserving cultural Environments. Spon Press, London, 86 pp.
Morey, M. (2003) Comparación del desarrollo del turismo de masas con el de las poblaciones animales. El caso de las Islas Baleares. Territori, Turisme i Medi Ambient 1: 5–18.
Morey, M. (2004) Turismo y medio natural en las Baleares. Una relación difícil y de futuro incierto. In: M. Castelló and F. Sastre (eds.) Espais naturals protegits, el paper de la propietat privada. INESE: Palma de Mallorca, 239 pp.
Morey, M. and Martínez-Taberner, A. (2000) Environmental conservancy strategies in the Mediterranean Islands. In: L. Trabaud (ed.) Life and Environment in the Mediterranean. WIT Press: South Hampton, NH, pp. 345–386.
Seguí Llinàs, M. (1995) Les nouvelles Baléares. La rénovation d'un espace touristique mythique. Editions L'Harmattan: París, 232 pp.
Villanueva Aranguren, J.A. (ed.) (2002) Tercer Inventario Forestal Nacional 1997–2006. Illes Balears. Subdirección General de Montes, Ministerio de Medio Ambiente: Madrid, 336 pp.
Wong, P.P. (ed.) (1993) Tourism vs. Environment: The Case of Coastal Areas. Kluwer: Dordrecht, pp. 9–15.
Yll, E.-I., Perez-Obiol, R., Pantaleon-Cano, J. and Roure, J.M. (1997) Palynological evidence for climatic change and human activity during the Holocene on Minorca (Balearic Islands). Quaternary Research 48: 339–347.

Chapter 13
The Maltese Archipelago

L.F. Cassar[1], E. Conrad[1], and P.J. Schembri[2]

A view over the ramparts of Valletta to the overurbanized landscape beyond (drawing by J. Makhzoumi)

13.1 Introduction

The Maltese Islands are a group of small, relatively low islands situated in the central Mediterranean some 96 km south of Sicily and 290 km north of the coast of Libya (Fig. 13.1). Their total land area is c.316 km^2. This island group consists of three inhabited islands: Malta (246.5 km^2), Gozo (65.8 km^2) and Comino (2.9 km^2) together with a number of small, uninhabited islets each less than 10 ha. Collectively, the islands have a coastline of 189.6 km. Amongst the Mediterranean Islands, the Maltese archipelago has received least attention, possibly because it is so close to Sicily and the Italian mainland, and because it has a limited habitat

[1]International Environment Institute, Foundation for International Studies, University of Malta, Malta

[2]Department of Biology, University of Malta, Malta

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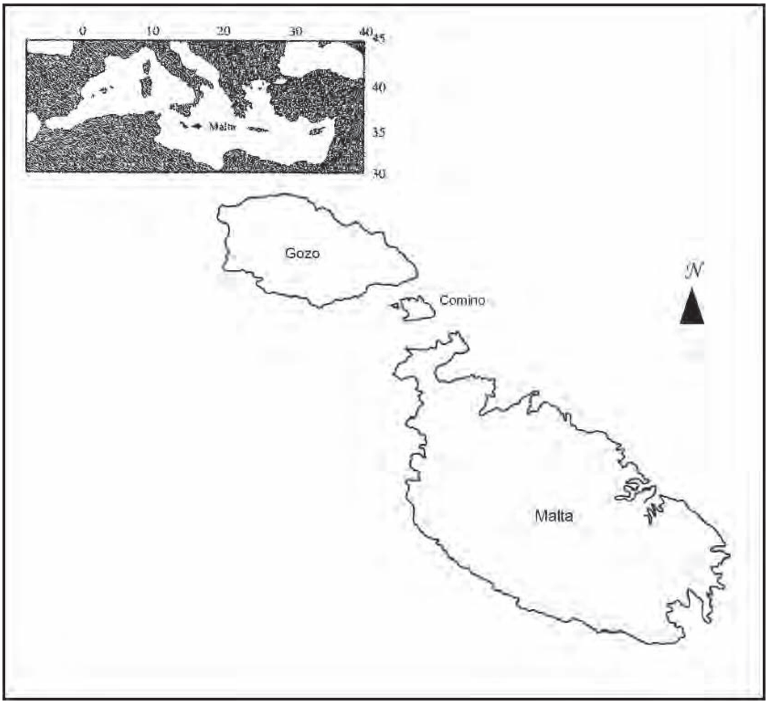

Fig. 13.1 Location map of the Maltese Archipelagos

diversity. There are no mountains on any of the Maltese Islands and therefore none of the climatic, edaphic or biotic phenomena associated with such landforms. However, the biogeography of the Maltese Islands is interesting, not least as a case study of how the present day biota has been assembled and has changed as a result of climatic and edaphic changes, and particularly as a consequence of human-induced perturbations to the local environment. The islands also support a number of endemic forms which are of intrinsic scientific interest for the light they throw on the phylogeny and biogeography of their group, and for the wider evolutionary processes they reflect. Such forms are also important culturally since they are unique to the Maltese archipelago and therefore form a valuable part of local, regional and global natural heritage.

The Maltese Islands have a long and diverse history of human occupation, dating back some 7,500 years to the Neolithic. Over time, the Islands have been governed by a succession of rulers prior to achieving independence in 1964. In such a small land area, human occupation inevitably exerted a significant impact upon the Islands' natural elements, often resulting in their modification and in the production of a landscape which is very much cultural. Although the same may be said of many areas of the Mediterranean, the particular constraints of a small island state make the interaction between what is natural and what is human-induced even more marked; as a result, many natural elements may be more properly described as semi-natural. The constraints of a small island state also render the achievement of a balance between economic and demographic growth and conservation of natural resources both difficult and urgent. The Maltese Islands clearly illustrate this constant strife between development and conservation, with a growing human population and one of the highest population densities in Europe, resulting in an increasing urban footprint, at a considerable environmental cost. This conflict is particularly relevant given the Islands' economic dependence on tourism. What is required therefore is a balance between preserving the country's assets and potential, whilst allowing for its dynamic and changing character.

This chapter provides a review of the physical and biotic elements of the Maltese environment, particularly the biogeography and the major changes that occurred during relatively recent geological past, notably the Quaternary. The chapter also reviews the cultural dimension of the Maltese Islands, giving an account of the influence that human activity has had on the terrain and of the resulting cultural elements, which make up the Maltese landscape. Present and future challenges are also outlined.

13.2 The Physical Environment

13.2.1 Climate

The Maltese climate is typically Mediterranean and strongly bi-seasonal, with characteristically hot and dry summers and mild wet winters. Although the average annual rainfall is 530 mm, of which some 85% falls during the period October to March (the wet season), it is highly variable from year to year. The mean monthly temperature range is 12–26 °C and temperature never falls too low to inhibit vegetation growth, although it does occasionally reach zero during the coldest months (Chetcuti et al. 1992). On the other hand, maximum summer temperatures of up to 45 °C have been measured at ground level, and such high temperatures may be detrimental to vegetation, especially seedlings (Haslam et al. 1977; Lanfranco 2002). Relative humidity is consistently high all year round, mostly ranging from 65% to 80%. Wind is common, with as much as 87% of the days of the year experiencing some wind.

13.2.2 Geology and Geomorphology

The archipelago is located on a shallow shelf, known as the Malta Plateau, which forms part of a submarine ridge that extends from the south Sicily promontory to the coast of North Africa. The water depth on the Malta Plateau, particularly around the islands and in the Sicilian Channel, is relatively shallow reaching a maximum of some 200 m although it is mostly less than 90 m. The Malta Channel (i.e. the region between the Maltese Islands and North Africa), on the other hand, is much deeper, and in places exceeds 1,000 m. The area beyond the eastern periphery of the Malta Plateau, known as the Sicily-Malta Escarpment, reaches abyssal depths of more than 3,000 m.

The Maltese island group is composed almost entirely of marine sedimentary rocks of Tertiary age. These are mainly Oligo-Miocene limestones, including calcareous sandstones and marl. These closely resemble those of the mid-Tertiary limestones found in the Ragusa region of Sicily and the Sirte Basin of Libya. Quaternary deposits of terrestrial and lacustrine origin also occur in various localities. Globigerina Limestone and the Upper and Lower Coralline Limestones constitute the Islands' only mineral resources, apart from sea salt. These rock types are extensively quarried, the former for use as building stone, and the latter mainly for aggregate. The soils are of relatively recent geological origin and are characterized by their close affinity to the parent rock material and intensive modification through human agency.

Erosion of these rock types has created the characteristic Maltese landscape. The main geomorphological features are karstic limestone plateaux, hillsides covered with clay taluses (Fig. 13.2), gently rolling limestone plains, valleys (known locally as *widien*, see later) that drain run-off water during the wet season, steep sea-cliffs on the southern, southwestern and western coasts (Fig. 13.3), and gently sloping rocky shores to the north-east. The highest points are, respectively, Ta' Zuta on Malta (253 m) and Ta' Dbiegi on Gozo (191 m); thus, in contrast to other Mediterranean Islands, the islands support a number of minor freshwater springs, of which some are perennial, but no rivers or lakes.

Fig. 13.2 Karstic coastal landscape with boulder scree; the tower in the background forms part of a coastal defence system dating back to the 17th century (Photo courtesy of L. Cassar)

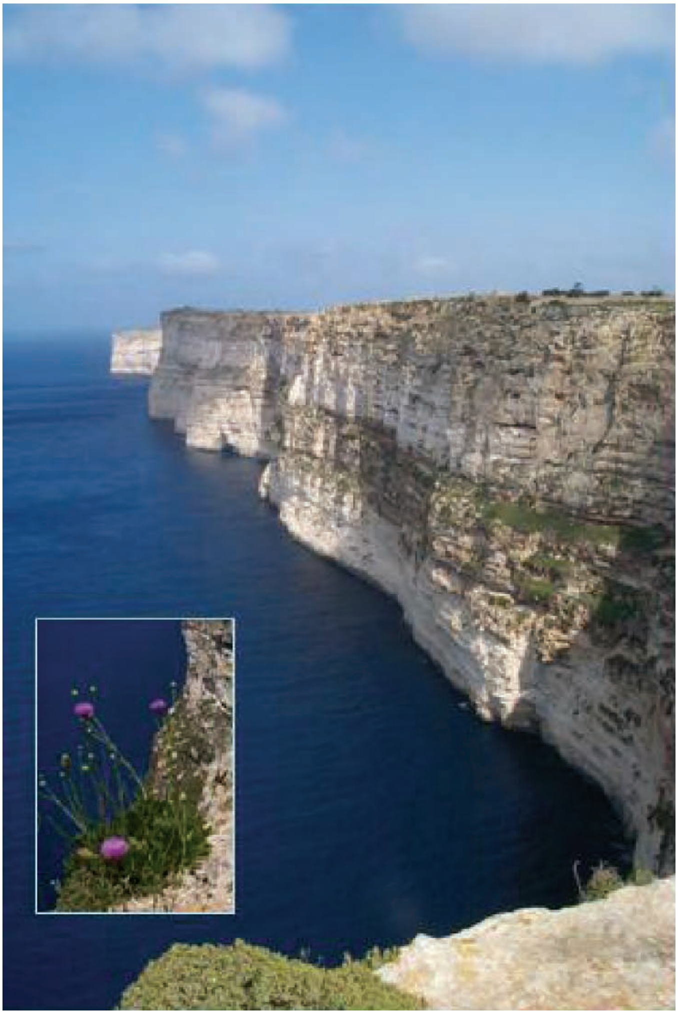

Fig. 13.3 Sheer sea cliffs at Ta' Cenc. Inset shows the endemic *Palaeocyanus crassifolius* (Photo courtesy of L. Cassar) (*See Colour Plates*)

The Coralline Limestones form cliffs as well as limestone-platform plateaux on which karstland develops (Fig. 13.4). The most extensive exposed formation is the Globigerina Limestone, which forms a broad rolling landscape, as is mainly evident in the central and southern regions of the main island and the southern and western regions of the island of Gozo. In exposed areas, particularly on broad slopes, this stratum is often covered by taluses of the overlying Blue Clay.

The topography of northern Malta and of northern and eastern Gozo is characterized by a series of hills capped by karstic plateaux consisting of Upper Coralline Limestone. These hills are separated by a gentle rolling landscape where the upper

Fig. 13.4 The Qarraba promontory at Ghajn Tuffieha, consisting of a remnant plateau of Upper Coralline Limestone with surrounding clay taluses and boulder screes (*rdum*) (Photo courtesy of L. Cassar) (*See Colour Plates*)

strata have been eroded down to the Globigerina Limestone layer, and sometimes even to the Lower Coralline stratum. Much of the upper regions of the hill slopes are covered by clay taluses, while the low-lying areas have, over the centuries, been utilised for agriculture and presently contain a soil cover. Topographic features of particular ecological importance are the *rdum* and *wied* systems. *Rdum* consist of almost vertical rock faces, so shaped either by erosion or by tectonic activity, with screes of boulders and other debris eroded from the rock face surrounding their base. As a result of the shelter these formations provide, these *rdum* boulder screes afford a suitable habitat for many species of flora and fauna, including many endemic forms.

Widien (singular: *wied*) are channels formed by either stream erosion during a previous and much wetter (Pleistocene) climatic regime, or by tectonic movement, or by a combination of both processes. Most of the *widien* in the islands are now dry valleys, carrying run-off along their courses only during the wet season. A few, however, drain perennial springs originating from perched aquifers and therefore attain the character of miniature river valleys with some water flowing throughout the year and with more extensive flow during the wet season. The natural water resources of the Maltese Islands are inextricably linked with the geology, since the only natural source of water is the rain falling on the islands' land surface and on groundwater. Thus, the Islands' water resources are entirely dependent on rainwater percolating through the porous strata to accumulate in aquifers.

It is probably true to say that the only reason why the Maltese Islands exist in their present state as an independent island-nation is due, in part, to their geology, as a consequence of which, the initial human colonizers found an adequate water supply to cater for their needs. There are many other small islands in the central Mediterranean region, none of which is an island-nation, and those which are not uninhabited at most support a few villages or small towns; it is probably not a coincidence that these islands have an inferior and less accessible natural water supply to that in the Maltese Islands.

Water seeps out of perched aquifers at the junction of the Upper Coralline Limestone/ Greensand and the Blue Clay to form springs, known as High Level Springs (but more properly as 'scarp-foot springs'). It is these springs that provided early settlers on the Maltese Islands with their freshwater supply and which, until relatively recently, have also provided a substantial proportion of the islands' freshwater needs. High-level springs are the only supply of freshwater available at the surface, apart from run-off in the *widien* and rainwater that collects in natural depressions following precipitation episodes. Some springs are perennial and run with diminished flow also in the dry season; these are of paramount importance, both in terms of water resources for human use and in terms of freshwater biota, some of which require a year-round supply of freshwater and therefore can only live in the vicinity of such an environment.

13.3 The Biotic Elements

13.3.1 Flora and Fauna

The flora and fauna of the Maltese Islands is relatively rich considering the limited land area, low habitat diversity and intense human pressure on the environment. Some 2,000 species of terrestrial plants and over 3,000 species of terrestrial animals have been recorded to date and many more certainly occur (Schembri 2003). Moreover, a number of species of plants and animals are endemic to the Maltese archipelago, while a larger number are sub-endemic, that is, with a distribution limited to the Maltese Islands and a limited number of islands in the region (the Pelagian group, Sicily and the circum-Sicilian Islands). Many of these endemic forms are relatively widespread in Gozo, albeit present as small populations or with limited cover, but are rather scarce or localized on the main island of Malta, and in some cases, absent altogether. This may be related to the more intense human presence on urbanized Malta relative to rural Gozo.

The biota of the Maltese Islands most closely resembles that of Sicily (Francini Corti and Lanza 1972; Hunt and Schembri 1999; Schembri 2003). However, it is not merely an appendage of that of Sicily, since there are a significant number of species that occur on the Maltese Islands but which do not occur in Sicily; these include a few North African species, others with a disjunct distribution that occur on the Maltese Islands and one or two other places in the Mediterranean, as well as a number of endemic forms (Schembri 2003). As a first step, explaining the present-day biogeography of the Maltese Islands requires an analysis of the tectonic history of the central Mediterranean region and of changes in sea level (Box 13.1)

Box 13.1 Quaternary sea levels and biotic changes

The marine regression that occurred between the Lower Pleistocene and early Middle Pleistocene [Oxygen Isotope Stage 16 – 690,000 years BP] (Hunt and Schembri 1999), during a very extensive glaciation, seemed to have facilitated another major influx of biota into Sicily and the Maltese Islands. Each of these episodes was followed by a prolonged period of isolation, which could have given rise to a fauna with a high degree of endemicity. This included the development of features such as gigantism, nanism and flightlessness in different species, e.g. glirids, elephants and the Giant Maltese Swan, respectively.

A further marine regression during the late Middle Pleistocene [between Oxygen Isotope Stage 8 – 300,000 years BP and Stage 12 – 490,000 years BP] may have brought about a third episode of immigration into Sicily and the Maltese Islands, when a physical connection between Italy and Sicily, and possibly with the Maltese group of islands, is thought to have occurred. This new fauna, termed the *Elephas mnaidriensis* fauna, had a distinct continental affinity, and nanism, although evident, was noted to be less pronounced than in the previous fauna, termed the *Elephas falconeri* fauna (Hunt and Schembri 1999).

Another major influx of immigrants to the Islands seems to have occurred towards the end of the Pleistocene, during a sea level lowstand [the Last Glacial Maximum, Oxygen Isotope Stage 2 – 22,000–17,000 years BP] as a result of extensive glaciation. This fauna has been termed the *Equus hydruntinus* fauna, and included species such as pine voles and toads (now extinct in the Maltese Islands). This indicates an unhindered land-bridge connection. Hunt and Schembri (1999) suggest that once isolated, the Maltese Islands were unable, spatially and ecologically, to support the full diversity of the Sicilian fauna. The latest influx of species into the Islands involves the arrival of humans c.7500–7000 BP (Hunt and Schembri 1999).

Although sea level lows are largely regarded as the main reasons for species influxes and invasions from Sicily, other phenomena, such as tectonic activity, could have taken place synchronously but totally independently of the rise or fall in sea level due to glaciation or crustal adjustment. Thus, new evidence of subsidence would modify and complicate a scenario based solely on relative sea level.

While the notion of a connection with the African mainland is possible during the Messinian marine regression, it is not likely at any other time since. This is because the maximum marine regression during the Quaternary is estimated to have been some 120 m, while depths between Malta and North Africa range between 200 and 800 m (see Hunt and Schembri 1999). Thus, species with North African affinity either reached the islands from the Maghreb during the Messinian and subsequently remained isolated on the Maltese Islands, or reached the islands at other times by passive dispersal, or both. The present paucity of forms with North African affinity fits both scenarios: the low number of such forms may be a result of the ancient African stock being replaced by more recent and better adapted colonizers, or else may reflect the difficulty of passive dispersal across the relatively wide seaway that separates the islands from North Africa, or both.

that may have established, and severed, land connections with Sicily and possibly with northern Africa at different times, as well as a knowledge of the present and past biota of adjoining lands that may have served as the centres of origin of the Maltese biota. To this must be added a knowledge of the role that humans have played in deliberately or accidentally introducing species into the Maltese Islands.

What are now the Maltese and Pelagian island groups (the latter comprising the islands of Lampedusa, Linosa and Lampione) and the Hyblean plateau of south-eastern Sicily are the emerged parts of the Pelagian Block, which constitutes the foreland margin of the African plate. The Pelagian Block was originally colonized by species from the European and African mainlands during the sea level lowstand associated with the Messinian Salinity Event. At the end of the Miocene, after much of the Pelagian Block became inundated, some of these colonizers differentiated in isolation on the emergent landmasses, one of which was the Maltese complex.

During the Quaternary, the Maltese Islands experienced further colonization episodes exclusively from Sicily during at least some of the marine regressions associated with the Pleistocene glaciations, followed by development in isolation of the populations that managed to gain a foothold. What is uncertain is whether these Quaternary colonizations occurred across land bridges which formed during sea level lowstands (as suggested by, e.g. Francini Corti and Lanza 1972; Thake 1985) or due to jump dispersal across the channel separating the Maltese group from Sicily. The latter mechanism may have been facilitated by a narrowing of the marine barrier during the Pleistocene marine regressions. It is most likely that both events occurred at some time or other. This scenario explains why some Maltese endemics, such as the Door-snail (*Lampedusa imitatrix*) and the Maltese Wall Lizard (*Podarcis filfolensis*) are genetically well-differentiated, good species. These represent forms derived from the pre-Quaternary Mediterranean biota that occupied the exposed Pelagian landmass during the Messinian Salinity Event and then became isolated on the different islands that formed following the final inundation of the Mediterranean at the beginning of the Pliocene. Such endemics may be termed ‘palaeoendemics’. These, or rather their ancestors, therefore reached the Maltese Islands when these were still connected with the Hyblean region of Sicily by an isthmus of dry land, prior to the Pleistocene.

The strong affinity of Maltese flora and fauna with that found in Sicily was noted by Soos (1933). By 10,000 BP, the end of the Pleistocene, these species had become extinct throughout much of their range, except in the Maltese Islands, where they continued to flourish, relatively unchanged, to the present day. Therefore, these species are the relicts of a preglacial Mediterranean biota; some of these species have no close relatives on the mainland, for example, the Maltese Rock-Centaury (*Palaeocyanus crassifolius*) and the Maltese Cliff-orache (*Cremnophyton lanfrancoi*), both of which belong to monotypic genera (Brullo et al. 1988; Lanfranco 1989). *Palaeocyanus* appears to be closely related to the genus *Centaurea*, but is more primitive than this and other related genera; its precise association to *Centaurea* is still uncertain, although it is now sometimes referred to the polytypic genus *Cheirolophus*. *Cremnophyton* has ancestral links with *Atriplex*, and seems to have had its origins in the sub-desert environments of the east. *Darniella melitensis*, another Maltese palaeoendemic flowering plant, is the only representative of this genus in Europe; the genus *Darniella* is largely of North African distribution, as is the genus *Chiliadenus* (Lanfranco 1989), represented on the Maltese Islands by the relatively common endemic *C. bocconei*. The Maltese *Darniella* and *Chiliadenus* attest to an important biogeographical link between the Maltese Island group and Northern Africa.

The above mentioned scenario of Quaternary colonisations also explains the larger number of endemic forms that are less strongly to very weakly differentiated from their Sicilian counterparts, sometimes so weakly that it is debatable if they are sufficiently different to warrant their distinction as geographical races (subspecies). These represent those species that reached the islands at different times during the Quaternary, mostly by dispersing from Sicily or nearby lands, and then became cut off from their mainland ancestral populations when the connection between the Maltese Islands and Sicily was severed by rising sea levels. These then differentiated in relative isolation, evolving genotypic and often phenotypic differences from their ancestors, in some cases to the point that they are considered new species even if they are closely related to mainland forms. Normally, the longer the isolation, the greater the differentiation from their Sicilian or mainland ancestors. Such species may be termed 'neoendemics' (Hunt and Schembri 1999).

There are, however, still some features of the biogeography of the Maltese Islands that the above model does not adequately explain. One of these is an eastern Mediterranean element in the biota (Schembri 2003). On the other hand active dispersal across land bridges connecting the Maltese Islands and the various surrounding lands, or across relatively narrow sea channels, is a reasonable assumption for mobile, eurytopic forms such as many vertebrates and flying insects. However, it is more difficult to understand how stenotopic forms with limited mobility, such as many terrestrial molluscs, and cryptofaunal, hypogeal and cavernicolous invertebrates, could have reached the Islands via these connections, especially given the relatively short times for which it is thought these links existed.

During the Pliocene, the Islands experienced a relatively long period of isolation followed by a physical land connection with Sicily during the Lower Pleistocene to early Middle Pleistocene, as suggested by vertebrate fossil evidence (Hunt and Schembri 1999). This episode was followed by another prolonged period of isolation during the Middle Pleistocene, when it is suggested that the Siculo-Maltese connection was inundated, possibly as a result of subsidence. Thus, the endemic species that evolved on the Islands are thought to have formed during a number of phases of geographic isolation from the mainland.

The Maltese endemic biota varies widely in the degree to which different forms have diverged from their closest relatives (Soos 1933); one interesting feature is the occurrence of small groups of closely related endemic forms. One explanation for this may be that Sicily and Malta were physically connected more than once, thus experiencing phases of colonisation by influxes of the ancestral mainland species or their descendants, followed by spans of isolation that over time led to speciation of the island colonisers (Thake 1985). Moreover, it must be borne in mind that very small, isolated populations are known to evolve rather rapidly (Stanley 1979).

Studies of raised beaches indicate that the level of the sea was c.150 m above the present level during the Middle Miocene, with a subsequent gradual decrease until interglacial sea levels reached 100 m above present mean sea level; this took place by the end of the Pliocene (Hsü et al. 1973). Notwithstanding, there is evidence that during the Late Miocene (Messinian), the Mediterranean Sea experienced a major regression. The collision of the African plate with the Eurasian plate closed the Rif and Betic Straits at the Mediterranean's western end, thereby cutting off the source of replenishment of the Mediterranean waters from the Atlantic (the eastern connection of the Mediterranean with the Indian Ocean had, by this time, already been severed). As the level of the major source of seawater from the Atlantic slowly decreased and the huge ridge which existed at the time across what are today the Straits of Gibraltar (Jebel Tarak-Jebel Moussa Strait) formed a barrier between ocean and enclosed sea, it is suggested that the basin eventually dried up. Even though major river systems discharged freshwater into the Mediterranean, the rate of evaporation was vastly higher. This led to the desiccation of the sea – the so-called Messinian Salinity Crisis. Thus, as the rest of the world's seas and oceans receded gradually, the Mediterranean Sea dried up rapidly and remained so for some 0.5 million years. Subsequently, at the beginning of the Pliocene, rifting at the Straits of Gibraltar enabled the Atlantic to flood into the desiccated Mediterranean Basin and re-establish marine conditions, although probably not catastrophically, as some accounts tend to suggest (Keogh and Butler 1999; Bassetti et al. 2005).

Throughout the Quaternary, eustatic sea levels continued to fluctuate, with lowstands occurring during glacials and highstands in interglacial periods. Thus, sea level in the central Mediterranean was approximately 120 m below present level during the Last Glacial Maximum and about 6 m higher than modern-day sea-level during the last interglacial (Brückner et al. 2003). It is expected, therefore, that the Hyblean plateau and the Maltese landmass would have been connected, or separated by narrow straits during glacials, when the relatively shallow submarine ridge between Malta and Sicily would have been exposed to varying degrees as a result of sea level drop, and consequently cut off during interglacials.

Therefore, the central region of the Mediterranean, including present-day Sicily and the Maltese Island group, would have received an influx of biota from surrounding landmasses during the Messinian due to the existence of somewhat broad terrestrial corridors or land bridges (see Box 13.1).

Hunt and Schembri (1999) suggested that the sequential development of the Maltese biota is characterized by a series of 'turnovers', that is, the replacement of one biota by another. The reasons why this occurs include: immigration by new biota which then replaces the older established one; changes in the physical dimensions of the islands consequential to eustatic sea level fluctuations; arrival of predators, including humans, in a previously predator-free ecosystem; and climatic change. All of these factors have operated at some time or another and have had a significant influence on the history of the Maltese Islands' biogeography (Hunt and Schembri 1999).

13.3.2 Vegetation

The vegetation of Maltese Islands may be grouped in three categories:

1. Communities that are part of the successional sequence (steppe, garrigue, maquis) towards the climatic climax (sclerophyll forest)
2. Communities which are either specialised to occupy particular habitats, or occupy habitats that are rare on the islands, or are relicts from a previous ecological regime, now surviving in a few refugia
3. Vegetational assemblages of disturbed habitats, which are those occupying land subject to periodic disturbance, usually related to anthropic activities

Prior to permanent colonization by humans, it is thought that the Maltese Islands supported significant tracts of Mediterranean maquis and sclerophyll forest, dominated by Holm Oak (*Quercus ilex*), Aleppo Pine (*Pinus halepensis*) and possibly other trees, with an undergrowth of smaller tree species and shrubs (Storch 1974; Evans 1971; Cutler 1972 in Renfrew 1972; Hunt 1997). These climax woodlands are the highest succession type of vegetation that can develop in the central Mediterranean climatic regime.

Early settlers cut down the trees for wood and to clear land for agriculture and habitation, and introduced sheep and goats whose grazing and browsing prevented trees from regenerating. The use of wood for fuel is also thought to have had a significant negative influence on the islands' woodland habitats. In the Maltese Islands, the native forest is all but extinct and only remnants persist within a handful of localities on the principal island. More extensive wooded areas nonetheless exist on the islands but all owe their origin to human activities (e.g. gardens, plantations, orchards, etc.). Although originally planted, some are now self-maintaining and self-regenerating, and therefore qualify as semi-natural woodlands.

Semi-natural woodland, dominated by Aleppo Pine *(P. halepensis*), occurs in a limited number of areas on the islands, however, only at one locality, namely Buskett in south-west Malta, is it comparatively well developed. This semi-natural wood, with minor naturally occurring stands of Mediterranean Oak (*Quercus ilex*), is relatively important as it represents the only well-established woodland ecosystem in the Maltese Islands and consequently supports a significant flora and fauna associated with this habitat type. Other areas on the island of Malta where remnant woodland ecosystems still persist, albeit restricted spatially, include Ta' Baldu and the contiguous Wied Hazrun, Mgiebah and Wardija, where copses of *Quercus ilex* still survive in embayments beneath the scarpline.

The only wooded areas of significance on Gozo are all the result of recent afforestation schemes with the exception of one site at Gnien Migarro (also known as Taht Xambrè) on the clay slopes surrounding Chambray. Other woodlands occur at Ta' Blankas on the limits of Xewkija and at Ta' Lambert. The Gnien Migarro site consists of a mixed woodlot mainly dominated by Aleppo Pines *(P. halepensis)*, while the latter two sites consist of cultivated Olive trees (*Olea europaea*). Another site that supports a copse of ancient olives, seemingly planted during the time of the Knights, is that appropriately known as Il-Buskett (small wood), located near the village of Nadur, south of and on the headwaters of Ta' Bingemma valley.

Maquis develops in small pockets where adequate shelter is available, such as on the lower reaches of valley sides and among boulder screes at the foot of escarpments. This community may consist of either naturally occurring species (e.g. *Rhamnus alaternus, Laurus nobilis*, etc. with associated understorey vegetation) or of archaeophytes such as carobs and olives, which form a phytosociological association referred to as the *Oleo-Ceratonion* assemblage.

The Barbary Thuja, also known as the Saradac Gum tree or Alerce (*Tetraclinis articulata*), is a monotypic conifer whose remaining populations are restricted to the thermo-Mediterranean zone of northern Africa, namely, across the Rif of Morocco, the Kabyle region in Algeria and a handful of localities in Tunisia, together with a few localities in southern Spain and four to six localities in Malta. This long-lived conifer is a palaeo-relict whose closest surviving relatives are species of the genus *Callitris* that occur in the subtropical forests of south-east Australia and nearby islands, e.g. New Caledonia (Blondel and Aronson 1999). Presently, the Maltese populations are restricted to a few localities, mainly on the northern coast of mainland Malta, but it appears that this species was more widespread in the past, and may well have been the dominant species in some types of mattoral (maquis) in the Maltese Islands. Evidence of this are the numerous small populations and individuals that occur in several remote localities, indicating widespread distribution.

The most widespread natural vegetation type present is the garrigue. Some garrigue communities are natural, others result from degradation of forest and maquis, particularly where removal of the original vegetation cover has caused such extensive soil erosion that large tracts of the limestone bedrock have become exposed and only patches of stony soil remain. Garrigue is characterized by low growing shrubs on a karst landscape. Many subtypes of Maltese garrigue exist; the principal ones are those dominated by Mediterranean Thyme (*Thymbra capitata*), Yellow Kidney Vetch (*Anthyllis hermanniae*), Olive-leaved Germander (*Teucrium fructicans*), Mediterranean Heath (*Erica multiflora*), and the endemic Maltese Spurge (*Euphorbia melitensis*). Mixed garrigues dominated by two, three or more of these species are also common.

Similarly, steppic assemblages, dominated by grasses, umbellifers, thistles and geophytes are widespread and result from degradation of the maquis and garrigue as a result of grazing and browsing as well as soil erosion due to the short but heavy rainstorms which are characteristic of the islands. Some steppic communities are, however, climactic or semi-climactic, with Esparto Grass (*Lygeum spartum*) on clay slopes, or with Beard Grass (*Hyparrhenia hirta*) and *Andropogon distachyus*. Other steppes are characterized by False Brome (*Brachypodium retusum*) or, rarely, by Canary Grass (*Phalaris truncata*). The more degraded steppes are characterised by Steppe Grass (*Stipa capensis*) and Goat Grass (*Aegilops geniculata*) and a variety of thistles (e.g. *Carlina involucrata, Notobasis syriaca, Galactites tomentosa*) and geophytes (e.g. Branched Asphodel *Asphodelus aestivus*, and Seaside Squill *Urginea pancration*). Steppic communities also develop on abandoned agricultural land, which is increasing in extent. Both the garrigue and steppe communities are widespread and considered the most commonly occurring natural vegetation assemblages present in the Maltese Islands. Climax maquis and garrigue communities develop in situations where edaphic factors and exposure hinder the development of climax forest.

A variety of other habitats that do not form part of the characteristic Mediterranean successional sequence (i.e. steppe – garrigue – maquis – woodland) also occur. In the coastal zone, these include coastal cliffs, low-lying rocky shores with gentle gradients, sand dunes, saline marshlands and transitional coastal wetlands, some of which are of prime scientific importance. Other habitats of importance include freshwater and inland rupestral communities. On gently sloping rocky shores, halophytic vegetation grows in isolated patches in the shallow saline soil that accumulates in pockets in the rock. The species present form part of the Mediterranean floral community referred to as the *Crithmo-Limonietum* or Aerohaline community.

Many local sandy beaches were backed by dune systems but at present very few still persist and even these have been much degraded due mainly to human activities connected with beach development for recreational use (Fig. 13.5). Sand dune ecosystems are thus amongst the rarest and most threatened of local ecosystems. Local dunes are dominated by the dune grasses *Elytrigia juncea* and *Sporobolus pungens*; until recently, Southern Marram Grass (*Ammophila littoralis*) was also present on some beaches, but this species has now been totally extirpated. Maltese coastal marshes are characterized by a muddy substratum on which a pool of brackish water collects in the wet season. During the dry season this water becomes progressively more saline until it finally disappears completely, leaving the marsh dry until the following wet season.

Rupestral assemblages dominated by shrubs occur on sheer rock faces and cliff/scree environments, mainly on the south, south-west and west coasts of the islands. Because of their relative inaccessibility, these habitats provide important refuges for many species of Maltese flora and fauna, including many endemics, amongst which are the two plant taxa (*Palaeocyanus crassifolius* and *Cremnophyton lanfrancoi*) belonging to monotypic genera, discussed with reference to palaeoendemics in the Special Topic later. The main freshwater habitats are those associated with *widien*. By virtue of the shelter provided by valley banks as well as by the availability of water, *widien* are among the richest habitats on the islands. Other freshwater habitats are temporary rainwater pools formed by rainwater that collects in natural depressions and hollows on rock during the wet season, and a few permanent ponds. In spite of being made up almost exclusively of limestone, the Maltese Islands have surprisingly few known deep caves. Those caves that have been explored biologically have revealed an impoverished but interesting biota with a number of endemic invertebrates.

Fig. 13.5 Ramla l-Hamra coastal dunes with surrounding agricultural terraces. The site also harbours several archaeological and historical artefacts (Photo courtesy of L. Cassar) (*See Colour Plates*)

Given the islands' high human population and the considerable land use, anthropogenic habitats have a large coverage. Such habitats are dominated by a variety of plant species consisting mainly of ruderals and aliens. Different types occur in association with agriculture, afforestation, abandoned fields, along roadsides, in disturbed coastal habitats and in urban areas.

13.4 Cultural Landscapes

The islands have been more or less continuously inhabited since around 7500 BP (Blouet 1967), that is, since the Neolithic when the first settlers arrived from Sicily. At present, the islands' total population is 402,668 and the overall population density is 1,274 persons/km^2 (National Office of Statistics 2005). The growth rate is 0.86% per year (National Office of Statistics 2004). Moreover, the resident population is augmented by substantial tourist arrivals, which average over a million per year (National Office of Statistics 2004b). It is hardly surprising therefore, that human influence is a key feature of the islands' ecology. Overall, some 38% of the land area is presently under cultivation, c.25% is built up, and the remainder is countryside. Human impact is thus highly significant as a cause of environmental/ecological change. Table 13.1 gives a summary of the main historic episodes, in terms of colonization of the islands.

Marked improvements in social and economic conditions during the last century or so have led to an increase in population and intensified human impact. The latter part of this last century witnessed a significant increase in both industrialization and

Table 13.1 Chronological list of human colonization in the Maltese Islands

Period	Event
5000–4000 BC	First known human settlement (agricultural life-style)
c.2000 BC	First invasion by bronze-using people (warrior-farmers)
c.1400 BC	Second invasion by bronze-using people (warrior-farmers)
800–480 BC	Phoenician colonization
480–218 BC	Carthaginian colonization
218 BC	Islands formally part of the Roman Empire
AD 395–870	Byzantine domination
AD 870	Aghlabite Arab occupation
AD 1091	Norman occupation
AD 1194–1266	Swabian rule (from present-day Germany)
AD 1266–1283	Angevin rule (from present-day France)
AD 1283–1412	Aragonese rule (from present-day Spain)
AD 1412–1518	Castilian rule (from present-day Spain)
AD 1518–1530	Holy Roman Empire rule
AD 1530–1798	Knights of the Order of St. John rule
AD 1798–1800	French occupation
AD 1800–1964	British rule
AD 1964	Independence

urban growth. Improvements in public transportation systems also contributed to an accelerated growth, making accessible the more remote areas (Cassar 1997). Moreover, intensive enemy action during World War II brought about further demographic dispersion, when whole families abandoned the heavily urbanized harbour regions and moved to the countryside, including the then entirely rural island of Gozo. Post-war economic diversification brought about commercial opportunities that added to the pressures on a shrinking countryside. In addition, in the late 1950s, tourism was identified as a potential source of revenue. From the environmental point of view, this industry added to the degradation of the littoral and contributed to the spread of the urban footprint, much to the detriment of the rural and semi-natural environment.

All the colonizers which successively ruled the Maltese Islands left their mark on the Maltese culture and landscape and endowed Malta with a unique identity, which continued to evolve after the Islands acquired independence. Over time, ways of living changed and many such developments were physically reflected in the landscape. The introduction of the goat, for instance, led to widespread grazing and subsequent alteration of habitats and changes in species composition. The need for firewood and for building materials led to widespread deforestation. The introduction of alien species produced changes in landcover; the South African *Oxalis pes-caprae*, for instance, is now widely established and produces carpets of yellow flowers which cover entire tracts of terrain and characterize the landscape at a particular time of the year.

Human influence on the landscape became especially marked as human activities became more diverse, and in the case of agriculture, more intensive. The latter activity produced one of the most spatially widespread cultural elements of the Maltese landscape, that is, the terraced hillslopes. Hillslopes were reclaimed for cultivation through the excavation of ‘steps’ in the hillside, producing a series of successive flat parcels of land. Soil was generally transported from other areas of the Islands, resulting in mixing of different soil types, as well as mixing with pulverized rock particles and organic debris, and the resulting production of soil complexes. Soil was generally retained within the land parcels by means of ‘dry’ limestone rubble walls. These were constructed with larger boulders on the outside and smaller rubble used as fill on the inside, and rely for their strength on the skilful positioning of such stones. It is of note that even within an area as small as the Maltese Islands, there are noticeable differences in the construction patterns of such walls from one place to another (Ellul 2005).

On the island of Gozo, where Blue Clay outcrops occur much more frequently than on Malta, the terrain is much more dynamic (Fig.13.6), and as a consequence, rubble walls are not deemed practical. These are therefore absent from some terraced slopes; however, their function has in part been taken over by the extensive use of prickly pear, and to a much lesser extent, the use of reed fences. These, like rubble walls, serve to delineate property boundaries. Reed fences are also designed to act as windbreakers. Both the prickly pear (*Opuntia ficus-indica*) and the Great Reed (*Arundo donax*) are species introduced to the Islands in antiquity, the former from central America following the discovery of the continent by Europeans, and the latter is presumed to have been introduced much earlier from Asia Minor. Despite not being native to the Maltese Islands, both species are now characteristic of the Maltese landscape. They also serve a socio-economic function, being utilised in various ways for both agricultural and domestic use. The decline of agriculture in recent years, and the consequent abandonment of land, has resulted in the lack of maintenance of terraces and rubble walls. In several areas, the latter have fallen into disrepair, and as a result, soil erosion rates have increased substantially. Ironically, however, the abandonment of fields has allowed the spread of prickly pears and reed stands.

The landscape of the Islands also reflects the rise and decline of other industries which were important to the economy at different times in the Islands’ history. Salt pans hewn into limestone platform shores were in the past important for production of salt (Fig. 13.7), although these have been largely abandoned in recent years as the importance of such production diminished. Some salt pans are however still used for domestic production. Other than salt, Malta’s only other mineral resource of significance is limestone. This is exploited through surface quarrying for both hardstone and softstone. Quarries are very often visually detrimental features of the landscape, particularly where these occur in sensitive contexts. However, quarries are also to some extent reversible, and the landscape is also characterized by disused quarries, many quite old, reclaimed for agriculture or as fruit orchards.

In a country with such a long history of human occupation and such a high human population density, settlement features are necessarily a key feature of the cultural landscape. A look around the built-up areas of the Islands suffices to illustrate the latter’s diverse history. The range of such elements extends from prehistoric temples to baroque churches, medieval palaces, military fortifications, and modern constructions. Of particular note is the Islands’ archaeological heritage, dating back to the Neolithic. At least 21 megalithic temples or the remains of

Fig. 13.6 The predominantly agricultural land use in Gozo is superimposed on the hilly terrain of the island, illustrating the inevitable merging of the cultural and natural landscape (Photo courtesy of L. Cassar)

Fig. 13.7 Salt pans at Qbajjar, Gozo, excavated in the relatively soft Globigerina Limestone (Photo courtesy of L. Cassar)

temples are known. These structures, which started being erected around 3500 BC show an increasingly sophisticated architecture, with lobed designs being progressively developed into trefoil, five-apsed, four-apsed and six-apsed structures. The temples, amongst the oldest free-standing stone buildings in the world, if not the oldest, fell into decline around 2500 BC, before the first pyramids in Egypt were erected (Trump and Cilia 2002). The Maltese prehistoric temples have been designated World Heritage Sites by UNESCO. Given the small size of the Maltese Islands, the concentration of such sites is highly significant. These, and other features from other periods in history, are often found in close proximity to each other, presenting a stark historical contrast which is, however, quite ordinary in the Maltese landscape. The growth of the built-up area is now resulting in a change from the traditional nucleated village settlement pattern constructed around the central church. Settlements are now increasingly merging into each other, producing a considerable urban mass, which dominates the eastern parts of the island of Malta. Gozo is still sufficiently rural to have maintained the traditional settlement pattern, although ribbon development along primary roads is starting to become significant.

13.5 Recent Environmental Changes

Since 1960, the archipelago experienced rapid economic growth which, although it improved living standards, in the absence of adequate spatial planning and environmental legislation, led to widespread insensitive urban development and degradation of the countryside. In 1995, the projected population for the year 2000 had been estimated at c.382,800, while it was estimated to reach 416,000 by 2020. This latter figure represented an increase of approximately 9·53% over the 1995 figure (Central Office of Statistics 1996). When considered in relation to the land area, the population of the Maltese Islands, and in particular that of the principal island, is very high. The overall population density in 1995 was 1,194 persons per km^2 while the population density of the individual islands was as given in Table 13.2. Based on population data from the Demographic Review of 2004, the most recent available, the total Maltese population stands at 389,771 (as opposed to a total resident population of 402, 668) with an overall population density of 1,274 persons per km^2, being the highest in Europe (NSO 2004). Population figures for the individual islands are presented in Table 13.2.

By the time national spatial planning legislation and other environment-related legal instruments were enacted, the population of the Maltese Islands had already grown considerably. The 1995 national census revealed a slow but steady rate of growth (Central Office of Statistics 1996). Furthermore, despite the fact that in the initial years of the 1990s, countries throughout Europe were experiencing widespread recession, economic trends in Malta showed consistent economic growth for the period 1990–1995, with an annual real growth in Malta’s GDP ranging from 4.5% to 6.3% between these years, a substantial albeit lower rate when compared

Table 13.2 Population density in the Maltese Archipelago (From: Central Office of Statistics 1996; NSO 2004)

	Malta	Gozo	Comino
Population in 2004	359,110	30,657	4
Population density (per km^2) 2004	1,461.6	456.9	1.4
Population in 1995	346,192	28,370	12
Population density (per km^2) 1995	1,409	422.8	4.3

to 8.4% in 1988 and 8.25% in 1989 (Planning Authority 1997). A relatively stable economy, coupled with such a high population density, brought about significant pressures on the overall balance between rural and urban regions (Fig. 13.8), resulting in a substantial increase in urban landcover. Table 13.3 gives an approximate chronology of changes in urbanization.

Nevertheless, population growth does not quite correspond with the rate of spread of urbanization. This was highlighted during a national conference on ‘Land and Housing Markets in Malta’, where it was indicated that during the last 30 years, new development occupied an area two and a half times the area built up in previous centuries (Structure Plan Technical Report 1.2; as reported in Planning Authority 1997). That is, in three decades, the urban land mass increased by two and a half times that taken up by development in 7,000 years of human colonization of the Islands. Between 1957 and 1985, it was reported that the urban area increased by 348% in Malta and by 226% in Gozo. Over this same period, the number of dwellings increased by 70%

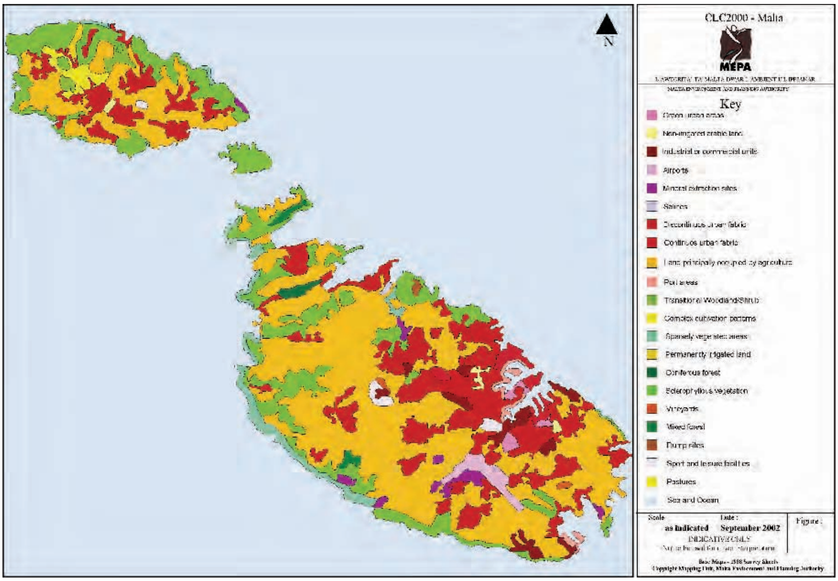

Fig. 13.8 Landcover map of Malta (Reproduced with Permission from Malta Environment and Planning Authority) (*See Colour Plates*)

Table 13.3 Changes in urban area over time

Period	Percentage Urban area
1955–1957:	5–6%
Mid-1980s:	16.5% (represents urban sprawl for the island of Malta only)
Presently (2005)	c.23% (represents urban sprawl for the islands of Malta and Gozo)
European average	8%

whilst the population increased by less than 10% (Planning Authority 1996), due to land speculation.

Not unexpectedly, the rapid economic growth experienced in the Maltese Islands over the last three or four decades resulted in a number of environmental problems, more so since adequate environmental legislation backed by modern spatial planning policies had not been installed until the early nineties, as already discussed. One area which probably suffered most, and where human pressure is most evident, is the littoral. Since the early days of tourism development some 40 years ago, many coastal areas were made more accessible as a consequence of road construction, and subsequently became more built up. Localities that demonstrate this are the Bugibba/Qawra region in Malta and Xlendi and Marsalforn in Gozo. Literally hundreds of apartments and tens of hotels and holiday complexes were built in these areas and in others in the last 30 years. In addition, an assortment of industrial, commercial and military installations, coupled with intensive agriculture, has over the centuries contributed to the decline of numerous coastal habitats.

The islands' coastline of a mere 190 km has been heavily impacted. Given the overall very high population density together with the additional million or so annual visitors, a large percentage of which reside in, and/or utilize coastal areas for recreational purposes, the overall impact on the coastal zone is significant, with habitats in coastal areas having been adversely affected, some irreversibly. Since only some 2.4% of the coast consists of sandy beaches, which are especially sought after for recreational use, it is hardly surprising that sandy and associated habitats are amongst the most impacted.

Other activities that have had a considerable influence on Maltese landscape are bird shooting and trapping. These activities have the status of a national pastime amongst a section of the Maltese population and have been practised for centuries. One manifestation of the impact of bird shooting is the numerous woodlots planted in the countryside, mostly on formerly cultivated land, to attract birds. While hunting has led to the widespread planting of such copses, trapping has led conversely to the clearance of indigenous vegetation for the setting up of clap-net sites.

The Maltese island group is largely devoid of large tracts of woodland, and most tree cover consists of pockets of archaeophytic assemblages associated with agriculture, mainly carobs, figs and olives, dotting the rural landscape. Traditionally this is where hunters practised their sport. However, since the 1970s, new fast-growing species, mainly acacias and eucalypts, became available, mostly through Government afforestation programmes, and bird shooters seized the opportunity to plant new fast-growing woodlots of these alien trees round field peripheries and then on derelict agricultural land which, with the increasing abandonment of agriculture, was becoming more available. At the present time, copses of eucalyptus and acacia trees dot the rural landscape, often taking the form of small 'islands' of trees surrounded by completely different habitats, and increasingly, with elevated shooting butts on permanent metal scaffolding. The visual impact of these 'hunting woodlots' is considerable. Additionally, the soil on which these copses are planted is also altered through depletion of its moisture content since eucalypts in particular have high water requirements, through alteration of its chemical composition as a consequence of the products of decomposition of the shed leaves, and through a reduced undergrowth compared to that under native and archaeophytic trees, suggesting that eucalypts and especially acacias may have allelopathic effects.

The setting up of trapping sites necessitates the clearance of the vegetation within a sizeable area of land, in order to make space for a roofed masonry hide, the clap-nets which take up the bulk of the area of the site, a cordon round the site where live, caged decoy finches are deployed on small stone cairns or shaped limestone blocks, and, sometimes, a space between the two clap-nets for a water trough as an added attractant for birds. Such trapping hides are usually established on abandoned agricultural land, where therefore the cleared vegetation consists of pioneer steppic species, or on karstic rock where then the vegetation that is cleared is natural rocky steppe or garrigue. Considering that an average trapping site occupies an area of some 60–70 m^2 and that is some localities there may be up to 150 such trapping sites per square kilometer, then the visual impact on the landscape is immense and likewise the impact on the natural vegetation. Not only is the natural vegetation removed to establish these sites, but the resulting disturbance encourages invasion by ruderal species. Herbicides are also occasionally used in order to clear the vegetation while the bird seed sometimes used as a lure introduces alien species into local habitats.

13.6 Landscape Conservation

In common with Europe, the Maltese landscape has been moulded over the years by both natural and anthropological forces. In view of the significant human impact, there is hardly a location within the Maltese Islands that does not bear evidence of human presence over the last seven millennia. The Maltese landscape can best be described as cultural rather than natural. Humans have had a profound effect on environmental development, initially through agriculture, and more recently, because of increasing industrialization and urbanization. The present Maltese landscape is almost entirely anthropogenic, and human activities are the single most important factor affecting the environment, a trend that will almost certainly continue, and possibly intensify, in the future.

Since early times human activity has had an impact on local ecosystems, starting with woodland clearance for arable and pastoral agriculture by the early settlers. Introduced sheep and goats prevented the trees from regenerating through their grazing and browsing activities. This process of deforestation has continued and has resulted in the almost total destruction of the native woodland and most indigenous trees. On the one hand clearance brought about a loss of existing biotopes (habitat of a biocoenosis) and biotic communities, while on the other it created increased niche space for new species to establish themselves. Further modifications took place systematically throughout the ages, in particular whenever the islands experienced economic prosperity and political stability. During the 1900s, the landscape continued to be modified, with pressures becoming greater as socio-cultural conditions improved and with technological advancement. Much of the land area of the islands is given over either to agriculture or to buildings and roads. However, agricultural land is being diverted more and more to other uses, mainly for buildings. Between 1956 and 1991, registered agricultural land area declined by 42% (Meli 1993). As a result, large areas of abandoned fields can be found across the Maltese Islands, still enclosed within an extensive network of rubble walls, characteristic of the Maltese rural landscape, showing that these areas had at one time contained soil and were cultivated. Built-up areas (residential and industrial) now occupy c.23% of the Islands (Malta Environment and Planning Authority 2006).

Some of the more significant threats to the environment include the clearance of natural habitats formerly for agriculture and now for building development, quarrying, and dumping of domestic and building waste. The tourism industry further contributes to the general decline of the countryside, especially in coastal areas. Of these anthropic factors, the most important is, doubtlessly, land use. The Maltese environment has been subject to great pressures from a variety of development related activities. As far back as the mid-1940s, various reports, proposals and draft legislation relating to land use, in particular building development, had been prepared, but no integrated national plan was ever drawn up (Ministry for Development of Infrastructure 1988). The result was haphazard, piecemeal, unregulated development leading to urban sprawl, abandonment of agricultural land, increased soil erosion, deforestation, increased quarrying activity, loss of countryside, loss of habitats and wildlife, and problems of contamination of water resources, pollution and waste disposal (Schembri and Lanfranco 1993; Cassar and Gauci 2005).

It is only relatively recently that there has been an active awareness of the need of protecting and conserving the islands' environment, of maintaining environmental quality and of controlling development. The early 1990s saw the enactment of two important pieces of legislation concerning nature and landscape protection. These were the Environment Protection Act (1991) and the Development Planning Act (1992). Notwithstanding their tardy enactment, these were setup with the aim of formulating adequate national environmental and spatial planning policies, taking into account various components, notably the community's social requirements and the environment at large. Under these legislative provisions, protected areas could be declared either following the criteria of the Environment Protection Act (1991), or those of the Development Planning Act (1992), or both. At the time, the Environment Protection Act only made provision for one type of protected area, the so called *nature reserve*. Although the 1991 Act was not specific as to the criteria for declaring areas as protected areas, the regulations published under it were initially based on measures aimed at bird protection and the conservation of habitats strongly linked to avifauna, as well as on national security concerns. The Development Planning Act, on the other hand, was more outward looking. Its companion *Structure Plan for the Maltese Islands*, set out a number of policies for Rural Conservation Areas (RCA Policies), which provide protection status for *Areas of High Landscape Value, Areas of Ecological Importance* (AEIs) and *Sites of Scientific Importance* (SSIs). The Structure Plan for the Maltese Islands and supplementary planning documents, which are the planning policy and implementation tools of the Development Planning Act of 1992, outline a number of policies concerned with conservation or which are of direct relevance to the natural and semi-natural environment.

In 2001, a new Environment Protection Act was enacted by Parliament to replace the Act of 1991 and its amendments and subsidiary legislation. The Act of 2001 is essentially a framework law with various mandatory provisions that grant the Minister responsible for the environment the possibility of issuing subsidiary legislation on issues concerning biological diversity, waste management, integrated pollution prevention and control, genetically modified organisms and environmental audits, among others. The Act also sets up three 'independent institutions' to implement its provisions, these being: a person or body to be the 'Competent Authority' for the purpose of the Act; a National Commission for Sustainable Development; and the Environment Protection Fund. The Commission for Sustainable Development, with functions related to the sustainable use of resources, operates independently of the Malta Environment & Planning Authority (the agency responsible for environmental protection and the rational use of land) and is answerable to the Prime Minister. Although the Commission has no executive powers, its advice *shall be considered as authoritative recommendations of best practice in achieving sustainable development*. Moreover, the new Act addressed the many shortcomings of the 1991 legislation; for instance, the term *nature reserve* was replaced by the more generic term *protected area* giving the possibility of designating different types of such areas, in accordance with international recommendations and practice. The Act of 2001 also makes provision for the conservation, protection and management of habitats in order to safeguard biological diversity in general, rather than particular biota.

13.7 Conclusion

If current trends persist in the future, as is expected, the biological resources of the Maltese Islands can be expected to be subjected to ever-increasing pressures. The human population, and with it the urban footprint, have been on a continual upward trajectory which seems likely to persist or even increase. Natural and semi-natural habitats are increasingly being restricted to small pockets of land within an encroaching anthropic footprint and associated activities. In a recent development, the designated zones for urban development are in the process of being expanded in what is ironically being called a rationalization exercise. On a more positive note, recent years have seen the enactment of several environmental regulations, particularly following Malta's accession to the European Union. Most habitats and species are therefore now afforded legal protection, at least on paper. In reality, however, legal protection is not always a guarantee of actual protection, as attested to by the fact that some development applications have been successful even if to the detriment of environmental assets, and at times in contradiction to established policy direction. Furthermore, enforcement capacity is regrettably still limited. Malta's wealth of natural and cultural heritage is substantial; nevertheless, it appears that development trends in recent decades, and the thrust to steer the country towards increased economic security, have occurred at the expense of this heritage, and hence to the detriment of future generations.

References

Bassetti, M.A., Miculan, P. and Sierro, F.J. (2005) Evolution of depositional environments after the end of the Messinian Salinity crisis in Nijar Basin (Se Betic Cordillera). Sedimentary Geology 188: 279–295.

Blondel, J. and Aronson, J. (1999) Biology and Wildlife of the Mediterranean Region. Oxford University Press: Oxford.

Blouet, B. (1967) The Story of Malta. Faber & Faber: London.

Brückner, H., Müllenhoff, M., Van Der Borg, K. and Vött, A. (2003) Holocene coastal evolution of Western Anatolia – the interplay between natural factors and human impact. In Commission International Pour L'exploration Scientifique De La Mer Méditerranée. Human Records of Recent Geological Evolution in the Mediterranean Basin – Historical and Archaeological Evidence (Santorini, Greece, 22–25 October 2003). Workshop Monographs, 24: 51–56.

Brullo, S., Lanfranco, E., Pavone, P. and Ronsisvalle, G. (1988) Taxonomical notes on the endemic flora of Malta. Giornale Botanico Italiano 122 (Supplemento 1): 9.

Cassar, L.F. (1997) Settlement patterns in the Maltese Islands: from early colonization to pre-independence. Geojournal 41(2): 137–144.

Cassar, L.F. and Gauci, P. (2005) The Influence of landscape change on ecological resources. In L. Buhmann, K. Beck-Koh (eds.) Landscape Architecture Proposals for Gozo IslandAnhalt University of Applied Sciences: Bernburg.

Central Office of Statistics [Malta] (1996) Census of Population and Housing Malta 1995: Final Report. Central Office of Statistics: Malta.

Chetcuti, D., Buhagiar, A., Schembri, P.J. and Ventura, F. (1992) The Climate of the Maltese Islands: A Review. Malta University Press: Msida, Malta.

Ellul, E. (2005) Il-Hitan Tas-Sejjieh. Bicc: Floriana, Malta.

Evans, J.D. (1971) The Prehistoric Antiquities of the Maltese Islands. London.

Francini Corti, E. and Lanza, B. (1972) Xviii Congresso Della Società Italiana Di Biogeografia: Note Conclusive Sulla Storia Del Popolamento Animale E Vegetale Delle Isole Circumsiciliane. Lavori Della Società Italiana Di Biogeografia (Nuova Serie) 3: 911–918.

Haslam, S.M., Sell, P.D. and Wolseley, P.A. (1977) A Flora of the Maltese Islands. Malta University Press: Msida, Malta.

Hsü, K.J., Ryan, W.B.F. and Cita, M.B. (1973) Late Miocene desiccation of the Mediterranean. Nature 242: 240–244.

Hunt, C. (1997) Quaternary deposits in the Maltese Islands: a microcosm of environmental change in Mediterranean lands. Geojournal 41(2): 101–109.

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Hunt, C.O. and Schembri, P.J. (1999) Quaternary environments and biogeography of the Maltese Islands. In A. Mifsud and C. Savona Ventura (eds.) Facets of Maltese Prehistory The Prehistoric Society of Malta: Malta, pp. 41–75.

Keogh, S.M. and Butler, R.W.H. (1999) The Mediterranean water body in the late Messinian: interpreting the record from marginal basins on Sicily. Journal of the Geological Society of London 156: 837–846.

Lanfranco, E. (1989) The Flora. In P.J. Schembri and J. Sultana (eds.) Red Data Book for the Maltese Islands. Department of Information: Valletta, Malta,pp. 5–70.

Lanfranco, S. (2002) L-Ambjent Naturali Tal-Gżejjer Maltin. [Sensiela 'Kullana Kulturali' Nu 45]. Pubblikazzjonijiet Indipendenza: Pieta, Malta. Malta Environment and Planning Authority (2006). State of The Environment Report 2005 [Online]. Available from: http://www.Mepa.Org.Mt/Environment/Index.htm?Soer/Mainframe.htm&1 [Accessed 19 April 2006].

Meli, A. (1993). Overview of agricultural land use in Malta. Options Méditerranéennes, Serie B (7):71–76.

Ministry for Development of Infrastructure (1988) Structure Plan Brief. Town Planning Division, Ministry for Development of infrstructure, Malta.

National Office of Statistics [Malta] (2004). Demographic Review 2004 [Online]. Available from: http://www.Nso.Gov.Mt/Statdoc/Document_View.aspx?Id=1487&Backurl=/Themes/Theme_Page.aspx [Accessed 8 January 2006].

National Office of Statistics (2005). New release No.146/2005 Special Observances [Online}. Available from: http://www.nso.gov.mt/statdoc/document_file.aspx?id=1

Planning Authority (1996) General Human Development Report Planning Authority: Floriana, Molta.

Planning Authority (1997) Structure Plan Review: Monitoring Report 1990–95, Volume II: Monitoring Data. Planning Authority: Malta.

Renfrew, J.M. (1972) Cultivated plants from Tarxien cemetery, Malta. Antiquity 46: 114–146.

Schembri, P.J. (2003) Current state of knowledge of the Maltese non-marine fauna. In Malta Environment and Planning Authority. Malta Environment and Planning Authority Annual Report and Accounts 2003. Malta Environment and Planning Authority: Floriana, Malta,pp. 33–65.

Schembri, P.J. and Lanfranco, E. (1993) Development and the natural environment in the Maltese Islands. In D.G. Lockhart, D. Drakakis-Smith and J. Schembri (eds.) The Development Process in Small Island States. Routledge: London, New York, pp. 247–266; Xv + 275 pp.

Soos, L. (1933) A Systematic and Zoogeographical Contribution to the Mollusc-Fauna of the Maltese Islands and Lampedusa. Archiv Für Naturgeschichte Zeitschrift Für Wissenschaftliche Zoologie Abteilung B Neue Folge 2: 305–353.

Stanley, S.M. (1979) Macroevolution: Pattern and Process. W.H. Freeman: San Francisco, CA.

Storch, G. (1974) Quartäre Fledermaus-Faunen Von Der Insel Malta. Senckenbergiana Biologica 55: 407–434.

Thake, M.A. (1985) The biogeography of the Maltese Islands illustrated by the Clausitüdae. Journal of Biogeography 12: 269–287.

Trump, D.H. and Cilia, D. (2002) Malta: Prehistory and Temples. Midsea Books: Malta, 320 pp.

Part III
Future Perspectives

Chapter 14
Landscape Strategies

J. Makhzoumi[1] and G. Pungetti[2]



Reconciling nature, culture and development in Mediterranean Islands

[1]Faculty of Agricultural and Food Sciences, American University of Beirut, Lebanon

[2]Cambridge Centre for Landscape and People and University of Cambridge, UK

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14.1 Introduction

The greatest asset of the Mediterranean Islands is *landscape*. In its broadest definition, *landscape* comprises physical resources, being natural, semi-natural and human, as well as cultural resources expressed in local perceptions and identity, traditional management practices, socio-economic and political systems. Mediterranean Island landscapes encapsulate a character of place that is quintessentially Mediterranean. They are microcosms of the basin's geomorphological, biological and cultural diversity, and equally a reflection of the historical coexistence of people and environment, as well as a reflection of insularity.

The broad, integrative understanding of *landscape* underpins the essence of a strategy based on both conservation and management. Accordingly, a landscape strategy acknowledges the twofold character of Mediterranean Island landscapes as (a) the *context* for evaluating environmental, ecological and cultural resources and (b) the *framework* for ensuring a sustainable future. Equally, landscape strategies become a roadmap to evaluate concerns, to recognise resource limitation and aspirations, to develop a future vision, to articulate objectives, and to propose the principles and framework for an equitable and sustainable future.

A landscape strategy is especially relevant in the Mediterranean Islands because of the diffused boundaries between natural, semi-natural and cultural environments, the interface between urban and rural, and the coexistence of traditional and contemporary lifestyles (Fig. 14.1). Furthermore, an integrative definition of *landscape* enables a landscape strategy to tackle current concerns and initiatives while building on existing legislation and implementation mechanisms, thus addressing concerns for conservation, tourism, local livelihoods and climate change. Given that *landscape* is a tangible reality which is readily understood and appreciated by professionals, administrators and lay people, *landscape strategies* can be more readily communicated, hence securing improved participation and support, and a bottom-up rather than top-down approach to future action.

This chapter is divided into three parts. The first part draws on the individual island chapters in this book (Chapters 7–13) to outline commonalities and divergences in terms of resources, conservation and developmental concerns. The second part elaborates the vision, aim and objectives of a landscape strategy in Mediterranean Islands. The last part, based on the outlined potentialities and limitations, proposes a conceptual framework for the formulation of a landscape conservation and management strategy.

14.2 Mediterranean Island Landscapes: Resources and Concerns

The islands reviewed in Chapters 7–13 share many commonalities. First among these is their exceptionally rich natural and cultural heritage. Geographical isolation accounts for increased levels of biological diversity and endemism, while spatial

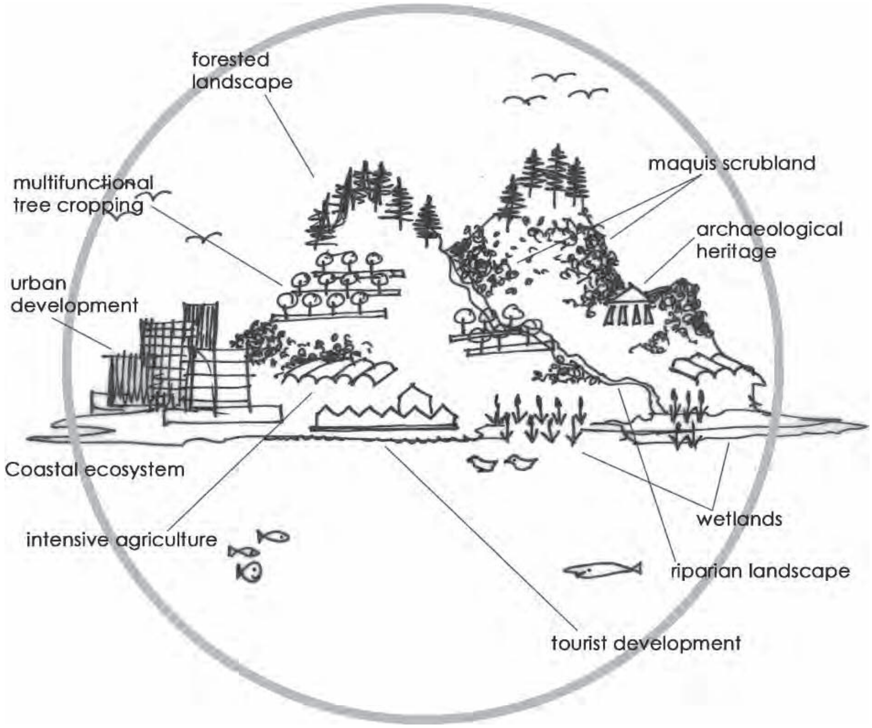

Fig. 14.1 A holistic approach to landscape strategies in Mediterranean Islands is integrative of traditional and contemporary landscapes, addressing equally conservation of natural environments and resources and the development of sustainable tourism and urban development

limitation contributes to geomorphic and landscape heterogeneity, which is amplified by continued human use and abuse.

The traditional rural landscape, a mosaic of arable agriculture, native woodlands, perennial tree cropping and herding, has shown in the past a balance between local ecosystems and land use (Pungetti 1996a). The character of isolation of the Mediterranean Islands, however, has often added environmental and socio-economic constraints to natural, climatic and seismic disruptions. As a consequence, the pace and scale of the 20th-century landscape development have changed, and ecological vulnerability has amplified, fast exceeding the resilience of island ecosystems. Furthermore, the pressure from population increase, rapid urbanisation and mass tourism, is undermining both landscape and ecosystems in the Mediterranean, especially in its islands. A discussion of key concerns about the Mediterranean Island landscapes is proposed below.

14.2.1 Wildlife Resources

Geography and climatic specificity have impacted Mediterranean flora throughout its evolution. In the ecotone between temperate and tropic zones, the composition of Mediterranean native flora is a mixture of temperate and tropical predecessors (Raven 1973). In the islands especially, the native flora is distinguished by high endemism and dominated by annuals, which constitute 50% of all species. Today, however, little remains of the native Mediterranean evergreen forest or of the diverse native fauna. Surviving relics include oak woodlands and the widespread, sclerophyllous shrublands, the maquis. Large mammals too have disappeared leaving only smaller ones; the largest faunal diversity in Mediterranean Islands is by far bird life.

Awareness of the exceptional wildlife resources has prompted listings of rare, endemic and endangered species of flora and fauna in all the seven islands presented in this book. Wildlife lists in Mediterranean Islands, although only indicative, provide some basis for action (De Montmollin and Stahm 2005). Indeed, listings in this volume's case studies were followed by various conservation measures depending on political, legal and administrative set-up. Sicily, for example, has established a total of 75 regional nature reserves and 4 regional parks since 1981, while in the Balearics two conservation laws dominate: the law for the Protection of Natural Regions, and the Law for the Conservation of Natural Spaces. These place 40% of the islands under some type of protection. The European Network of Natura 2000, moreover, has proposed 28 areas in Crete alone for protection as Sites of Community Interest. In Corsica, furthermore, nature conservation is organised at a regional scale through the Parc Naturel Régional de Corse, while at the local level Conservatoire de l'Espace Littoral et des Rivages Lacustres protects sites on coastal Corsica and Natural Zones of Ecological Faunistic and Floristic interest. Finally, in the Maltese Archipelago, the first legislation concerning nature and landscape protection is the Environment Protection Act (1991) and the Development Planning Act (1992).

Despite these considerable measures, wildlife conservation in the Mediterranean Islands is hindered by three sets of obstacles: legislative, physical and socio-cultural. 'Overlapping of laws and jurisdictions' within each island not uncommonly 'renders conservation ineffective' as in the Balearics, while confusion regarding the designation of 'nature reserve' and 'protected area' can hinder action as in Malta. Further complications arise because nature protection laws, apart from those of Cyprus and the Maltese Archipelago, are dictated by mainland authorities, like in France (Corsica), Spain (Balearic Islands), Italy (Sicily and Sardinia) and Greece (Crete). National Governments allocate budgets and propose broad conservation strategies that are not always responsive to both the ecological and the socio-economic context of Mediterranean Islands. On the other hand, local authorities are often easily coerced into overriding protection laws. In Sardinia, for example, the attempts at landscape protection expressed by national and regional legislation have been ineffective because land developers have continued to benefit from exceptional *permissions* (Chapter 8).

Physically, apart from the highly urbanised and industrial areas, wildlife habitats are distributed throughout the Mediterranean Islands. Coastal wetlands, seasonal watercourses, mountain peaks and traditional rural landscapes, individually and collectively, harbour native flora and fauna. Short of placing entire island landscapes under protection, which is not feasible, the extent and distribution of habitats becomes a major obstacle to wildlife conservation. More significantly, nature conservation cannot be achieved through legislation and zoning alone. As elsewhere in the Mediterranean, the biggest obstacle to nature conservation is local awareness and perceptions. For example, maquis scrubland, the dominant semi-natural wildlife habitat on Mediterranean Islands, is generally under-valued, perceived as 'degraded lands' and as such a target for low density development, golf courses and agriculture production (Chapter 11). The reason lies partly because maquis scrublands are abundant but also because they are not seen as being worthy of conservation vis-à-vis forested land (Thirgood 1987). The fact that protection often prevents local communities from gaining access to parks and protected areas is anther obstacle. The banning of local inhabitants and livestock in the Samaria Gorge in Crete, for example, has clearly resulted in decaying of the vernacular structures of forestland, overgrown rather than managed, which is subject to reoccurring fires.

Although the case studies reflect a perceptible broadening in nature conservation strategies to move outside the confines of 'protected zones', for example, nature trails in Cyprus (Chapter 9) and nature protection in urban and suburban areas in Corsica and Malta (Chapters 10, 13), the conservation of wildlife in the Mediterranean Islands will need to embrace not only the natural ecosystems, but also the semi-natural, the rural and the cultural ones. Tackling wildlife conservation through a landscape approach is an alternative that is discussed later in this chapter. A landscape approach will shift the focus of conservation from spatial zoning and physical planning towards evolving natural and cultural processes, landscape connectivity and ecological corridors (Pungetti and Sluis 2002). Furthermore, a landscape approach to nature conservation will more likely be inclusive of local communities because *landscape* includes not only environmental resources, but also cultural values and uses (Pungetti 2001a). Traditional landscape management, vernacular rural practices and social customs play all a big role in nature conservation, as does legislation. Therefore, they all need to be integral to wildlife conservation within the landscape of Mediterranean Islands.

14.2.2 Environment, Climate and Water Resources

The Mediterranean is distinguished by exceptional environmental conditions and resources. A geographic location between the deserts and areas with a truly temperate climate has been as influential in shaping the Mediterranean climate as local geomorphologic variations and human disturbances. Mediterranean Island ecosystems are characteristically arid and semi-arid, which renders them vulnerable to excessive human use and abuse. Ecosystems are fragile, as environmental degradation is rapid and often irreversible. Moreover, the integrity of island ecosystems is increasingly threatened by global climate change. Ever present climatic stresses in the semi-arid Mediterranean will be further aggravated and destabilised by changing temperatures, regimes and reduction in rain fall (MEDALUS 1993). There is increasing evidence that climate change is altering flowering and nesting times, the distribution of birds, butterflies and marine organisms, and more alarmingly leading to extinction (Lovejoy and Hannah 2004). In the future, islands in the Mediterranean, as elsewhere in the world, will be especially susceptible to rising sea level and the damaging impact this might have on coastal landscapes and ecosystems.

Environmental degradation and climatic changes are inextricably linked to sustainable resource management, especially water. Traditionally, rural communities managed resources efficiently, responding to climate limitations and resource scarcity, namely of water and soil. For example, multipurpose, perennial cropping, whether of cork oak as in Corsica and Sardinia, or olive and carob as in Cyprus and Crete, presented a model of sustainable use of land and water resources. The choice of native, or naturalised, trees ensured that they were well adapted to microclimate, water scarcity and soil conditions. Intensive modern agriculture and greenhouses have come to replace traditional rural landscape. By prioritising high productivity, intensive agricultural systems are not only wasteful of water resources but offer none of the environmental and ecological benefits of traditional agricultural systems.

Traditional stonewall terraces are a common and dominant feature in all Mediterranean Islands landscapes. Whether in the relatively flat terrain of the Maltese Archipelago (Fig. 14.2) or the steeper mountains in Cyprus and Sardinia, stonewall terraces are characteristic all over the Mediterranean. They are another example of traditional measures, which contribute to the recharge of groundwater resources and protection against erosion. Today they are increasingly replaced by 'false terraces' created with the use of bulldozers (Chapter 11) that lack stability and permanence. Similarly, seasonal watercourses, an important geomorphologic and ecological feature of the Mediterranean Islands landscapes, are frequently canalised (e.g. in Sardinia and Cyprus), which prevents water from percolating into the ground and renders the riparian landscape equally useless to humans and to wildlife.

The consumption of domestic water is another concern. In the Mediterranean Islands in particular domestic water consumption has increased not only because of urban population growth, but also because of the tourist industry. High draw-off index, the ratio of withdrawal to water resources, is far from being sustainable; rather it increases the threat of seawater infiltration. Contemporary architecture and urban development similarly lacks responsiveness to the character of traditional towns and villages.

Coastal ecosystems are also under threat from contemporary development. The threat is partly physical, involving the concentration of urban, industrial and tourist development, but also environmental, because of increasing quantities of

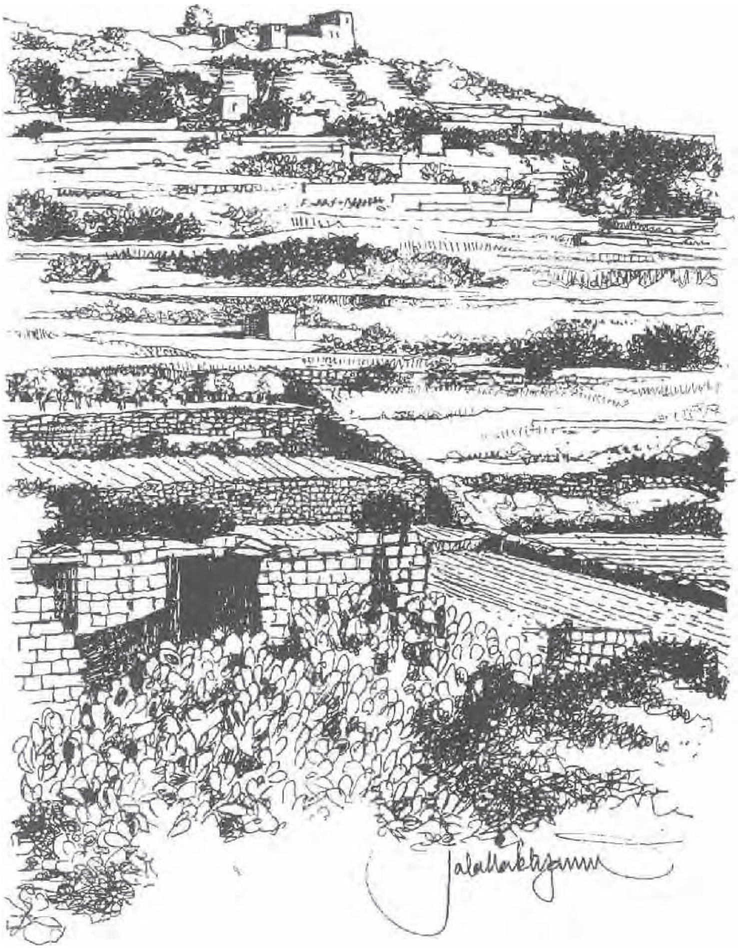

Fig. 14.2 Traditional Maltese landscape; a flat terrain with shallow, stone walled enclosures (Makhzoumi 2000. With permission from Elsevier)

sewage discharge. The Balearic Islands, for example, have taken a first step in protecting beaches and sand dunes through legislation that focuses on landscape.

Sustainable management of environmental resources in the islands necessitates integrated planning strategies, rather than compartmentalised, and piecemeal planning. The introduction of Environmental Impact Assessment is another example to ensure that long-term repercussions of contemporary projects are taken into the decision-making process as an alternative to current focus on short-term benefits.

14.2.3 Rural and Agricultural Resources

Successive civilisations over millennia transformed the native Mediterranean landscape into a predominantly rural cultural one. In this process, close associations came to evolve between climate, land and wildlife on the one hand, and people who inhabited these places on the other hand. The olive tree, more than any other element of the rural landscape, exemplifies cultural adaptation over time to the Mediterranean ecosystem with which it is closely associated (Polunin and Huxley 1987). Olive multi-use landscapes, like those of chestnut and cork oak, are an integral component of the mosaic of forest and scrubs, arable agriculture and herding that dominates the Mediterranean Islands.

It is known how traditional rural landscapes in the islands, as elsewhere in the Mediterranean, are threatened primarily by greenhouses and modernising influences that favour intensive monocultural cropping (Pungetti 2001b). Changes to agricultural production are however increasingly undermining traditional rural economies. Alternative work opportunities in tourism and in the service sector are a further cause of the changes in countryside values. If not carefully managed, this could lead to accelerated and widespread decline of the 'unique biological, ecological and cultural productivity and stability leading to more frequent and more destructive wildfires, and to accelerated soil erosion and flooding' (Naveh 1998, p. 24). Such a transformation is more noticeable in the small island of Malta, where agricultural land as a percentage of the total island area declined from 56% in 1957 to 38% in 1985 (Chapter 13), and in north Cyprus, where the destruction of rural landscapes has also reflected the loss of olive trees.

To add to this, the loss of agricultural lands and rural abandonment equally undermines the scenic and aesthetic quality of island landscapes, crucial for the tourist industry. Moreover, increasing rural abandonment is a common feature in the inland areas of the islands. This requires dynamic alternatives to revive local economies in villages and inland settlements. In Sicily, for example, agro-tourism has been introduced in the last decade, equally to sustain the rural economy and complement coastal tourism (Chapter 7).

Traditional rural landscapes, however, should not be valued strictly in terms of agricultural and tourist productivity. The fact that they are sustainable themselves, serve to shelter native flora and fauna, and protect valuable environmental resources, should be taken into consideration in their evaluation. Just as significantly, traditional rural landscapes sustain traditional uses and management practices, which in turn bind people and landscape and strengthen local and regional identity. Nor should the role of traditional rural landscapes as embodying the character of place, that is, the *genius loci*, be ignored. Rural landscapes are closely associated with Mediterranean Island landscapes and play an important role in marketing island tourism. Traditional rural landscapes, retaining both natural and cultural heritage, are indeed custodian of the islands' biological diversity, as well as their unique traditional culture, and are therefore particularly worthy of protection.

14.2.4 Human Settlements and Urbanisation

The Mediterranean Basin is a bridge that facilitates contacts between ethnic, religious and culturally diverse societies which are occupying it. The Mediterranean is the birthplace of some of the oldest, most deeply rooted cultures and it is the region where the three monotheistic religions of Christianity, Islam and Judaism originated. This cultural and spiritual background has undeniably influenced society, policy and economy, and in turn influenced the people that shaped their lands and shelters.

Being a place of dynamic economies and policies on the one hand, and of valuable natural and cultural resources on the other hand, the Mediterranean Basin has been always a place of conflict, conquerors and battles, with no exception to present times. It is understandable then that settlements of natives, with the exclusion of harbour towns, have sought protection from conquerors in the interiors and especially in the inland highlands. Historically, this particular location of human settlements has also affected the local economy. Accordingly, the capital cities and the deep spirit of the islands were often inland as in Malta. In Corsica, for example, it was the mountains, not the sea, that were considered as the source of food and livelihood (Chapter 10), while in Sardinia the sea was a passage for foreigners and enemies, and the mountains the shelters of the native tradition (Chapter 8).

Since the 1950s, however, population dynamics and the distribution of settlements have changed rapidly due to a shift in lifestyle, tourism increase and consequently economic directions. On the one hand, island populations are increasingly urbanising, and on the other cities and urban development are predominantly located in coastal areas (Leontidou et al. 1997). Moreover, urban population is growing at a faster rate than the total population, with urban growth patterns favouring capital cities and regional centres. Despite space limitations, indeed a key constraint in the islands, population densities vary considerably from one island to another. Of the 5,000 Mediterranean Islands and islets, two, i.e. Sicily and Sardinia (25,708 and 23,818 km^2 in turn) are large, three medium-sized, Cyprus, Corsica and Crete (9,251, 8,682, 8,400 km^2 in turn) and some 4,000 islands have areas of less than 10 km^2 (Hopkins 2002). Population densities too vary. For example, as illustrated in previous chapters the population density in the Maltese Archipelago is extremely high (1,274 inhabitant/km^2) while that in Corsica very low (30 inhabitants/km^2).

Coastal conurbations not only fragment and eventually displace the natural and agricultural landscapes, but also cause homogenisation of the traditional landscape mosaic. This in turn threatens the character of place and the ‘image’ associated with the Mediterranean Island landscape. Similarly, coastal urbanisation and suburbanisation threaten the health of marine and coastal ecosystems and undermine the health and quality of the environment. To varying degrees, urban, suburban and contemporary development is increasingly overtaking the coastal zones, likewise in the Balearics, Sardinia, Cyprus and in Crete. Urban and suburban Valletta, Malta’s capital city, for example, occupies alone around one third of the island surface area.

The inevitability of urban and suburban growth on one side, and the contribution of tourism to the local economies and livelihoods on the other, dictate more flexible strategies for future development. Particularly, sustainable urban greening, nature pockets and other measures will need to be incorporated into conservation strategies to both improve the quality of urban living and 'puncture' the urban wall that has come to define the island coastlines. Planning strategies will need to balance urban development with landscape protection and wildlife conservation, and moreover need to promote a type of resource use which does not undermine environment and ecosystem in the coast.

14.2.5 Tourism

The adverse impact of coastal urbanisation in Mediterranean Island landscapes is compounded further by coastal tourism. The combination of mild climate, beautiful landscapes and a rich historical and cultural heritage, have made the Mediterranean region, especially since the 1960s, a popular tourist destination. And because Mediterranean tourism seeks 'sun and sea', it has resulted in exceptionally high population concentrations, both of native and visiting communities, along the coastline. Conflicting interests have inevitably clashed and are difficult to reconcile. Land speculation, corruption and illegal constructions of any sort, especially along the seafront, have contributed to the destruction of the coastal landscapes, and consequently to undermine marine and coastal ecosystems and resources. Buildings too can degrade the landscape if not harmoniously merged with it, as do commercial expansions, golf courses and sport grounds, replacing traditional rural landscapes, coastal wetlands and dunes.

Unplanned tourist development in a fragile environment like the Mediterranean, places with no doubt increasing demand on scarce resources, especially on coastal land and potable water. Tourism not only consumes resources, water and land, but also generates sewage and solid waste which is costly to dispose of. Its impact on the environment is more critical when considering that Mediterranean tourism, presently estimated at 110 million visitors/year, is likely to double in the next 20 years (Myers and Cowling 1999).

Nevertheless, Mediterranean Island economies are heavily reliant on tourism. Although tourism is certainly affected by the quality of accommodation, it is also conditioned by the 'attractiveness' of destinations, i.e. the quality of their coast, water and environment. It is hence necessary here to plan for tourism in the context of the available local resources and of the carrying capacity of coastal ecosystems. Alternative strategies for island tourism are necessary to provide for destinations that are diverse in character, i.e. mountain, rural and agricultural, and that are not seasonal, i.e. summer.

Rural tourism and agro-tourism can certainly ensure economic return to the larger island community, as in the case of Akamas in Cyprus (Chapter 9) and Sicily (Chapter 7). These and other activities, such as those related to wildlife conservation, bird watching, botanical exploration, trekking, ecological tourism, archaeological visits, and last but not least culinary and artisan values and education, have brought not only economic advantages, but have also eased development pressure on the coast.

14.3 Landscape Strategies: Aim and Objectives

Since the 1990s, the Mediterranean Basin has become the focus for a variety of regional strategies. Its geographical location, i.e. as a crossing between eastern and western cultures, Asian and African states and the European Community, together with its status as a world biodiversity hotspot and as a cultural hub of western and eastern ancient civilisation, in combination explain the past and recent interest. The rapid environmental degradation of marine and coastal ecosystems, and the increasing rate of natural resource depletion are further factors prompting local, regional and global initiatives to protect the Mediterranean environment and its fragile islands.

The *Mediterranean Strategy for Sustainable Development* (MSSD) is a key proactive approach that is closely aligned with proposals for a landscape strategy tackling the Mediterranean Island landscapes (UNEP 2005).

Towards Sustainable Tourism in the Mediterranean Region, the manifesto of the Mediterranean Greens adopted in Palma de Mallorca in 2003, is another example of regional action with the aim of conserving and enhancing landscapes, and cultural and environmental heritage. The goal is to maintain a balance with the other productive sectors, improve quality of life and working conditions of the local hosting communities, seek long-term development strategies and enhance local democracy.

Regional action by *The Mediterranean Wetland Strategy* (MedWet) endorsed in 1996 reflects continuing concern with ecological and landscape value of wetlands globally (López and Correas 2003). The goal of the strategy is to stop and reverse the loss and degradation of the Mediterranean wetlands, as a contribution to the conservation of biodiversity and to sustainable development in the region. The *WWF Forest Conservation Strategy in the Mediterranean*, prioritises forests and woodlands (ibid.). The *MED Forum: Agenda 2000* is yet another initiative, albeit one with the aim of empowering local communities through 'the Network of Mediterranean NGOs for Ecology and Sustainable Development' (ibid.).

A landscape strategy for the Mediterranean Island landscapes, it is argued, should serve as an integrating framework that has the potential to overcome the overlap in environment and conservation strategies in the islands (Chapters 7–13) and similarly in the Mediterranean, as discussed above. A landscape strategy can therefore embrace a holistic, innovative approach that has the potential to curb landscape and environmental degradation and enhance the diversity of the Mediterranean Island landscapes. The European Landscape Convention defines landscape as 'a zone or area as perceived by local people or visitors, whose visual features and character are the result of the action of natural and/or cultural (that is, human) factors' (Council of Europe 2000, p.1). This definition reflects the idea that landscapes evolve through time, as a result of being acted upon by natural forces and human beings. It also underlines that a landscape forms a whole, whose natural and cultural components are taken together, not separately.

The *aim* of a landscape strategy for the Mediterranean Island Landscapes (MILs) is to conserve and enhance their character, quality and distinctiveness, as a natural and cultural heritage for the benefit of the island inhabitants, and as a foundation for ecologically, economically and culturally sustainable future development. Three objectives are established within the above aim: (a) to maintain and enhance the character, diversity and specificity of MILs; (b) to promote sustainable development and land management that respects the character of the place and contributes towards ecological, environmental, socio-economic and cultural objectives; and (c) to integrate, support and complement existing strategies in order to promote coordinated actions. These objectives are illustrated below.

14.3.1 To Maintain and Enhance the Character, Diversity and Specificity of MILs

Landscape character is the perceptual impact of the various elements of a given landscape both at the local level, i.e. a village and its surroundings, and at the regional level, i.e. the entire island. Variations in landform, vegetation cover, land-use pattern, historic and contemporary development, combine to produce a distinct landscape character in each of the seven islands illustrated in this book. For instance, the flat, predominantly urbanised character of the Maltese island landscape is very different from the mountain-dominated character of north Sicily. On the contrary, the hilly stone-terraced, olive dominated character of Cyprus landscape is quite similar to that of Crete. The highly urbanised and tourist dominated coastal landscape, on the other hand, has a very similar character in all Mediterranean Islands.

Indeed landscape character accounts for a distinct spirit of place and region, *genius loci* and *genius regionis* respectively. Landscape character moreover is closely associated with the local island identity, and it is as significant as its resources, historical heritage and wildlife. In order to protect and enhance the diverse landscape character, however, it is necessary to protect the natural and cultural heritage of the MILs, and equally to protect and enforce their local identity.

14.3.2 To Promote Sustainable Development and Land Management that Respects the Character of the Place and Contributes Towards Ecological, Environmental, Socio-economic and Cultural Objectives

Sustainable development, it is known, implies that current generations should meet their needs without compromising the needs of future generations. A degraded Mediterranean environment, especially in the Mediterranean Islands, endangers the very asset which makes the region 'so unique, especially in agriculture and tourism' (UNEP 2005, p. 3). The poor management of their scarce natural and cultural resources will with no doubt compromise economic development, quality of life and social stability.

The four objectives of sustainable development in the Mediterranean Strategy for Sustainable Development (ibid.) reflect the interdependence of economic development, social equity, environmental protection and improved governance. These objectives constitute similarly the basis for sustainable development in the Mediterranean Islands. Economic development should enhance, and not undermine, MILs resources. In addition, it should reduce social disparities, should actively aim to change unsustainable production and consumption patterns, and should ensure the sustainable management of island resources. Above all, the framework for governance action and implementation should be improved at the local, national and regional levels.

14.3.3 To Integrate, Support and Complement Existing Strategies in Order to Promote Coordinated Action

The scale and complexity of MILs preclude compartmentalised approaches to biodiversity conservation, environmental sustainability and development, that is, ones with a single focus like urban development. Acting separately, these single approaches have often proved to be ineffective and more often counter productive. The synergistic impact of coastal tourism and urbanisation in MILs, for example, produces a chain of negative outcomes that reach far beyond coastal landscapes. This impact contributes to rural abandonment by undermining traditional agricultural economies. By contrast, planning for sustainable futures will entail a synergistic, holistic approach that simultaneously tackles those natural, ecological, socio-economic and cultural processes that are affecting the MILs.

In this holistic context, the landscape strategy for MILs serves as the framework for action, an umbrella that has the potential to integrate on the one hand existing strategies, laws, action plans and initiatives on nature conservation, environment, agriculture and contemporary development, and on the other hand, the diversity of stakeholders such as local and regional authorities, professionals, developers and local communities.

14.4 Landscape Strategy Principles

To fulfil its aim of conserving and enhancing the character, quality and distinctiveness of the MILs, landscape strategies must respond to the environmental, socio-economic and cultural specificity of these islands (see Section 10.2). In this section it is argued that landscape ecology can provide holistic, dynamic and integrative principles to guide the formulation of landscape strategies.

As a science, landscape ecology has the potential to accommodate the complexity of natural and human ecosystems characteristic of MILs. Introduced in the late 1930s by Carl Troll, landscape ecology developed a spatially explicit landscape approach which is hierarchical and includes human influences (Forman and Godron 1986; Naveh and Lieberman 1990; Farina 1998). Landscape ecology's holistic and hierarchical principles, it has been argued (Pungetti 1996b; Makhzoumi and Pungetti 1999; Jongman and Pungetti 2004), can guide strategies for landscape evaluation, conservation policies, sustainable planning and landscape management. In this context, ecologically informed landscape strategies become a means for both conservation and development, a tool for careful natural resources management, and a capital for planning a sustainable future for the MILs.

If *landscape* is defined as the visible manifestation of natural and cultural processes interacting in space and over longer and shorter time spans (Makhzoumi and Pungetti 1999), then in the context of landscape ecology it becomes 'a heterogeneous land area composed of a cluster of interacting ecosystems that is repeated in similar form throughout' (Forman and Godron 1986, p. 11). It is this overlapping of ecosystems, landscapes and cultures that underpins landscape ecology's holistic and hierarchical approach to the evaluation and management of the Mediterranean landscapes. The approach is even more justified in Mediterranean Islands, because spatial limitations and temporal evolutionary processes have resulted in even greater alignment between ecosystems and landscapes. Hence landscape ecology becomes the framework that has the potential to simultaneously evaluate the evolution of MILs, and to provide a tool for sustainable planning and management.

Five principles, illustrated below, are proposed with the aim of guiding landscape strategy formulation in the MILs: (1) adopting a holistic framework; (2) accepting a multifunctional format; (3) moving from biodiversity to ecodiversity; (4) considering landscape connectivity; and (5) prioritising on cultural diversity.

14.4.1 Adopting a Holistic Framework

A holistic outlook has its roots in the ecosystem theory, which advocates the study of processes and relationships linking *all* components in a given ecosystem rather than analysing them separately. The focus, a 'real' tangible landscape, leads to a holistic approach which is responsive to the specificities of MILs. Alternatively, an appreciation of the hierarchical organisation of landscapes alerts to their continuity and contiguity from the smallest mappable unit to the totality of the island landscape (Fig. 14.3). Spatial limitations and the vulnerability of island ecosystems dictate a holistic, hierarchical approach not only in understanding the island ecosystems themselves, but also in the subsequent management of their natural and cultural resources.

A holistic approach, moreover, offers several advantages. First, it considers past, present and future. History is central to understanding MILs, as *past* processes

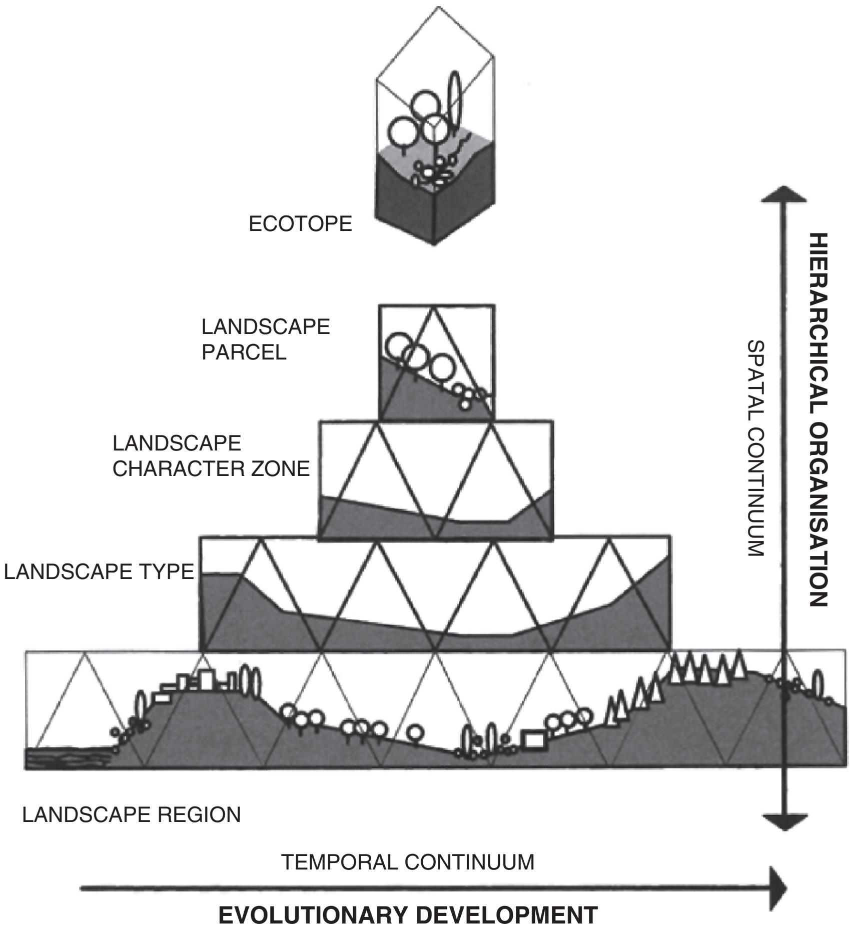

Fig. 14.3 Temporal/evolutionary and spatial/hierarchical understanding of landscape forms the foundation of holistic landscape design strategies (Makhzoumi 2000. With permission from Elsevier)

provide a dynamic context within which *present* landscapes need to be assessed, and *future* strategies formulated. Second, a holistic approach breaches the urban/rural divide, accepting that urbanised and contemporary commercial landscapes are simply another component of the diverse island landscape mosaic. Third, dealing with the interrelation between human societies and their open and built living environment, a holistic, hierarchical perspective bridges the ecological realm of sciences with the cultural realm of humanities. Therefore, an interdisciplinary and transdisciplinary framework is necessary in approaching the mosaic of natural and cultural island landscapes.

Ecological landscape design and planning, for example, is one approach that draws on concepts from landscape ecology to address the natural and cultural specificity of MILs. As demonstrated in several case studies (Naveh and Lieberman 1990; Makhzoumi and Pungetti 1999) landscape design and planning, informed by landscape ecology, become a means to realise efficient management of MILs, integrating conservation priorities, sustainable development and local community livelihoods.

A holistic hierarchical approach therefore is a *necessity* that is born out of increased spatial and functional alignment between ecosystems and landscape in Mediterranean Islands. A holistic approach, it is argued, enables the balancing between the protection and conservation of biodiversity and traditional rural landscapes on the one hand, and demand on natural resources and landscape caused by urbanisation and tourism on the other. Maintaining this balance is paramount in the island ecosystems. Therefore, a transdisciplinary framework is called to allow for coordination between the various stakeholders (both local and central authorities, NGOs and local communities), a pooling of resources (financial and expertise), and a type of solution-oriented, practical planning, that is responsive to MILs.

14.4.2 Accepting a Multifunctional Format

The concept of Multifunctional Landscapes (MFLs) implies sustainable use and management of natural and human resources. MFLs were central to sustainable resource management in traditional Mediterranean rural landscapes. The use of stone terraces in marginal landscapes to conserve soil and ensure efficient use of water in agriculture is an ancient practice. Intercropping and pastoral uses associated with cork oak, chestnuts, olive, carob trees and vines is another embodiment of MFLs. The trees, valued for their fruits (e.g. cork, chestnuts, olives, carob pods and grapes), accommodate a range of agricultural and pastoral activities. Such native or naturalised trees are well adapted to the semi-arid environment (Pungetti 1995; Makhzoumi 1997). It is understandable that traditional rural landscapes in the Mediterranean are referred to as agro-silvo-pastoral as they combine all three activities within their multifunctional framework. Above all, MFLs embody the Mediterranean character of place and region.

MFLs are not only sustainable in themselves, but in turn sustain the regional landscapes of islands, conserving soil and water in ravines and in marginal landscapes. If one considers their spatial extent, the loss of MFLs will invariably impact the island landscape, environment and ecosystems of the Mediterranean Islands.

The concept of an MFL is as valuable today as it was in the past. It is at the same time a living model for sustainable resource management, and an inspiration for efficient landscape design and planning. Reinterpreted into the contemporary scene, MFLs integrate ecological (habitats), economic (production), socio-cultural (recreation), historical (heritage and identity) and aesthetic (psychological well-being) dimensions of landscape (Brandt et al. 2000).

Applied to the Mediterranean contemporary landscape, a multifunctional model becomes at once a tool for protecting the rural landscape while aligning it to present social and economic needs. The model has been applied equally to integrate traditional multi-use olive and carob plantations into tourism development and in the conservation of community woodlands (Makhzoumi 2003).

14.4.3 Moving from Biodiversity to Ecodiversity

Biodiversity is the variability of living organisms equally in terrestrial, marine or aquatic ecosystems, including the diversity within species, between species and of ecosystems (Wilson 1992). Biodiversity is increasingly a priority in nature conservation not only because of the fundamental concerns to protect flora and fauna diversity, but also because biodiversity is a valuable resource locally and globally (Bail 2000). In the mentioned context of an ‘ecological bridge’ (Naveh 1998), the Mediterranean landscape has facilitated the movement of species between the three continents, Asia, Africa and Europe. The high levels of plant diversity and endemism is hence one outcome. MILs as such are the pillars supporting this ‘ecological bridge’; Sicily, Corsica, Sardinia, the Balearic Islands, Malta, Crete and Cyprus figure high as regional mini-hot spots (Chapter 4).

The close affinity between human managed landscapes and biodiversity is equally characteristic of the Mediterranean. The diversity of landscape components in traditional Mediterranean landscapes is another example of this affinity. The six landscape types associated with biodiversity that are listed in the CBD, the Convention of Biological Diversity, i.e. agricultural, dry and sub-humid lands, forest, inland waters, island, marine and coastal, are integral to the traditional landscape mosaic. All these landscape types can be found in MILs, constituting thus a further alignment between ecosystems and landscape in the Mediterranean Islands.

Here as elsewhere, the economic value of biodiversity is fourfold: *direct value*, as consumable output of timber, herbal products and recreation; *indirect value*, in terms of ecological services, as contributing to the health and integrity of ecosystems; *optional value*, in terms of possible future direct and indirect values; and *non-use value*, namely, intrinsic values, whether cultural, spiritual or aesthetic.

Biodiversity in the Mediterranean is as dependent on the natural setting, as it is on traditional rural landscapes and related cultural practices including grazing, burning and deforestation. The high levels of plant diversity and endemism are clearly associated with the fine-grained landscape mosaic of oak, cypress and pine woodlands, of maquis open evergreen scrublands, of olives and carob orchards, of pastoral and agricultural production, and last but not least of species introductions. Plant diversity is furthermore the result of the historical landscape management of logging, burning and grazing, which maintains evergreen open woodlands and maquis habitats.

In this wider context it is suggested to move from biodiversity conservation to ecodiversity conservation. Drawing on the holistic framework of landscape ecology, the broader concept of *ecological diversity* is therefore proposed, as better reflecting the close and interdependent relationship between biological and cultural diversity in the Mediterranean (Naveh 1998) and as integrating biological, ecological, landscape, historical and scenic values. In this framework, ecodiversity conservation should focus equally on biodiversity preservation as well as on the protection of rural cultural landscapes.

14.4.4 Considering Landscape Connectivity

Human ability to change landforms and land use changes may undermine the integrity of ecosystems. Landscapes are at once the habitat and the spatial means for species movement and dispersal, and as such a means for species survival. Fragmented landscapes which are eventually reduced to isolated enclaves, fail to serve as either. Informed by landscape ecology, biodiversity conservation has in the last 20 years shifted from a focus on 'nature reserve' towards alternative measures to promote landscape connectivity (Pungetti 1999).

Specifically, in Europe and North America, the search for dynamic frameworks to overcome landscape change and fragmentation has resulted in two dynamic conceptual approaches: ecological networks and greenways. These provide for spatial connectivity ensuring the movement and dispersal of species (Andresen et al. 2004; Fabos and Ryan 2004; Gobster and Westphal 2004). The aim of greenways and ecological networks is to maintain biological diversity, landscape heterogeneity and ecosystem integrity. An *ecological network* is defined 'as a framework of ecological components, e.g. core areas, corridors and buffer zones, which provides the physical conditions necessary for ecosystems and species population to survive in human-dominated landscapes' (Jongman and Pungetti 2004, p. 3). Whilst *greenways* have been developed as means to facilitate the movement of species and people via corridors, *ecological networks* embrace the wider landscape in a coherent ecological framework. Both have however the objective of conserving species and habitats.

MILs, as discussed earlier, serve as a habitat to an exceptional diversity of species, as their fine mosaic provides the continuity and ensures species survival. The latter is yet another point of alignment between MILs and ecosystems, and a key to the conservation of ecodiversity in the islands. MILs are in addition a living model of ecological networks. The components of Mediterranean rural landscapes, equally to greenways and ecological networks, ensure in fact spatial continuity and facilitate the movement of flora and fauna (Pungetti 2005). The landscape of the Kyrenia Region in North Cyprus, likewise, is a living example of ecological networks: the forest along the peaks forms a linear core; maquis along the higher foothills forming a buffer zone; and ravines linking forest to the coast are transverse corridors (Makhzoumi 1996).

Finally, the concepts of (a) landscape connectivity, that is, overcoming environmental fragmentation through ecological networks, combines in many ways the other two concepts of; (b) multifunctional landscapes, that is integrating more than one use within a defined spatial framework and (c) ecodiversity, that is, a combination of biodiversity and landscape heterogeneity. The three concepts (a, b, c) are noticeably closely associated and provide together a dynamic framework for holistic landscape planning and management in MILs, a framework that focuses on nature conservation and is inclusive of contemporary activities (Fig. 14.4) (Makhzoumi and Pungetti 1999).

14.4.5 Prioritising Cultural Diversity

In ancient traditional regions like the Mediterranean, humans had a grand effect on his environment and shaped the land in many different ways. These cultural landscapes, product of different cultural successions, should hence be viewed not only

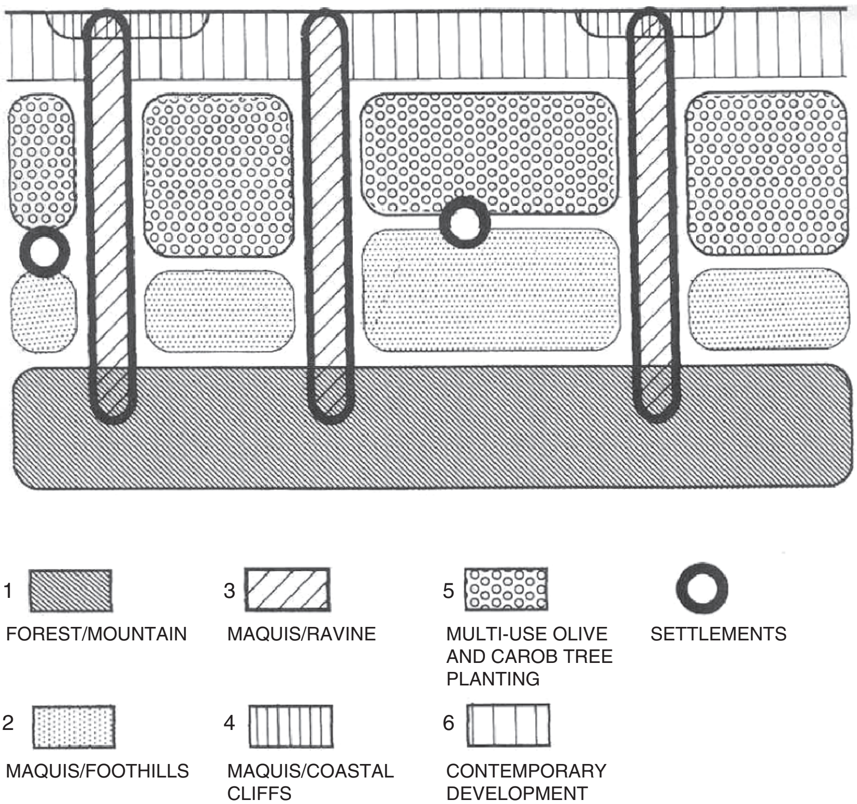

Fig. 14.4 Proposed conceptual model for the sustainable development of the Kyrenia Region landscape in Cyprus (Makhzoumi and Pungetti 1999. With permission from Routledge)

at present, but also in the context of the past, looking at historical processes to assess how far societies have differently used and abused their environment, and eventually call for remedies to improve our human relationship with nature.

Biological diversity, aesthetic characteristic and cultural background are elements to explore in the evolutionary process of any landscape. The next step is to investigate whether these are typical of a specific region, and whether the landscape is being threatened or preserved. In the Mediterranean Islands, nevertheless, the cultural landscape is under enormous pressure and traditional methods of management are disappearing. Therefore every aspect on the cultural landscape should be researched and established promptly, and on this foundation new guidelines for its protection and development should be laid down. One possibility is to follow the best practices available, which had a positive influence on the environment, with minimum transformation and without destruction.

The traditional MILs, however, are increasingly being fragmented, transformed and replaced by commercial landscapes. Survey and documentation of the MILs need therefore immediate consideration, as they not only represent a significant part of the Mediterranean historical and cultural heritage, but also show often ecologically stable and environmentally sustainable design and planning (Pungetti 2003). Yet documentation is not in itself sufficient and should be followed by the evaluation of the regional landscape heritage, public recognition and stewardship. This can be achieved by communicating the historic, cultural and symbolic values of the traditional landscape, as passed to the present island culture by previous generations. It is essential, furthermore, to investigate the local experience of landscape in the context of the different islands. This will provide insight and knowledge about peoples' attitudes, cultural constructs and feelings regarding their landscape and the environment as a whole.

As it has been shown in this book, the transformation of landscape goes beyond the physical environment, to include social and cultural values. Although this is a general concept, the specificity of the Mediterranean Islands is that economies and development still prevail over environmental consideration. There is a need to make governments and the public aware of the value of the traditional MILs, in order to facilitate the adoption of strategies and policies for their protection and conservation.

Awareness clearly, through education and participation, is an essential step to take in order to advance successful strategies for MILs. Ecological landscape design and planning, it has been argued (Makhzoumi and Pungetti 1999), although creative and intuitive cannot alone achieve future environmental sustainability and long-term ecological stability. This scenario requires efforts outside the professions and necessitates addressing cultural values in the contemporary Mediterranean society. An investigation of the current view of the humans/nature relationship within the dynamic context of cultural changes becomes thus fundamental to the search for values in MILs design and planning (Pungetti and Romano 2004). This moreover entails a continuing dialogue on the cultural meaning of landscape and nature, in order to discover people's social and cultural perceptions and cultivate in them environmental awareness. Ecological and environmental education, furthermore, is a powerful tool for increasing public awareness, while the creative contributions of art, poetry and literature can involve the community and enhance its cultural perceptions. Therefore it is suggested to explore simultaneously these two vertical directions: the top-down environmental education and the grass-roots community involvement.

Finally, the complexity of human interference in the Mediterranean requires a new consideration of the nature/culture relationship. The human-maintained balance between natural forest, semi-natural maquis and cultivated components has contributed to ecological stability, biological diversity, and attractiveness of the MILs. At a practical level, this traditional cultural landscape retains a delicate ecological balance between availability and use of natural resources. At a theoretical level, it is part of the Mediterranean cultural heritage, and therefore should be protected and conserved. The traditional cultural MILs can indeed serve today as a living example of sustainable landscape development, as a reflection of a mutually beneficial relationship between humans and nature that existed at different times and in different places throughout history.

14.5 Conclusions: The Future of Mediterranean Island Landscapes

The five proposed principles, i.e. holistic framework, multifunctionality, ecodiversity, landscape connectivity and cultural diversity are mutually inclusive. In combination they can guide the formulation of landscape strategies in Mediterranean Islands. Such type of strategies, when guided by these principles, will be synergistic and equally addressing concerns for landscape protection, biodiversity conservation and sustainable development.

Landscape strategies informed by ecological principles will moreover inevitably accept the cultural setting of MILs, and invariably will widen their focus on 'pristine nature' to include traditional cultural landscapes. Broadening the conceptual approach from ecology to culture is imperative because in the Mediterranean landscape planning is bound up with land uses. As Naveh (1998, p. 42) puts it, 'these landscapes being the tangible meeting point between nature and mind cannot be conceived, studied and managed by conventional, mechanistic and reductionist bio-ecological approaches and methods'.

Scientists, conservationists and planners are slowly adjusting nature conservation to respond to the specificity of the Mediterranean, and embracing the holistic, transdisciplinary approach of landscape ecology. Yet within the island context, the starting point is to concede to the scale and spatial limitations of MILs, to accept that the landscape is predominantly managed, and to focus on the existing fine rural mosaic as the basis of Mediterranean Islands biodiversity and ecodiversity. However, there is a need to go further; greater awareness of landscape cultural values is a necessary consideration for the future planning of sustainable MILs.

Similarly, there is a gradual shift in conservation and sustainable development programmes towards greater inclusiveness of local stakeholders, local authorities and local communities. Scientists, conservationists and planner, again, are realising that public participation is central to the success of conservation strategies (Pungetti

2001c). Representatives of the central and municipal authorities, local NGOs and local communities are clearly key contributors in the landscape planning process. Their involvement gives valuable feedback to strategists and policies. Greater awareness and active participation eventually can serve to empower both local authorities and local communities.

Above all a landscape strategy, being inclusive, encourages a methodological framework that is practical, applicable and responsive to the specificity of each Mediterranean Island. The ecological, environmental and cultural values of these multifunctional landscapes are yet to be recognised, as well as their adaptability to new roles, albeit contemporary ones. Multi-use landscapes, a key component of ecological networks, can indeed serve as a means for urban and suburban greening (Makhzoumi and Gunduz 2002). In this context, multi-use landscapes can provide the tangible basis in planning for future MILs, in the way that they will continue to be sustainable environmentally, ecologically and culturally.

References

Andresen, T., Aguiar, F. and Curado, M. (2004) The Alto Douro Wine Region greenway. Landscape and Urban Planning 68: 289–303.

Aschmann, H. (1973) Man's impact on the the several regions with Mediterranean climates. In F. di Castri and H. Mooney (eds.) Mediterranean Type Ecosystems: Origin and Structure. Chapman & Hall: London, pp. 363–390.

Bail, C. (2000) The convention of biological diversity in an European perspective. Bulletin de l'Institut Royal des Sciences Naturelles de Belgique Biologie 70 (Suppl.): 21–23.

Brandt, J., Tress, B. and Tress, G. (eds.) (2000) Multi-functional landscapes: interdisciplinary approaches to landscape research and management. Conference proceedings, Roskilde, October 18–21, 2000. Centre for Landscape Research, Roskilde.

Council of Europe (2000) European Landscape Convention. European Treaty Series – No. 176. Council of Europe, Strasbourg.

De Montmollin, B. and Stahm, W. (eds.) (2005) The top 50 Mediterranean Island plants. Wild Plants at the Brink of Extinction, and What is Needed to Save Them. IUCN: Gland and Cambridge.

Di Castri, F. and Mooney, H. (eds.) (1973) Mediterranean Type Ecosystems: Origin and Structure. Chapman & Hall: London.

Fabos, J. and Ryan, R. (2004) International greenway planning: an introduction. Landscape and Urban Planning 68: 134–146.

Farina, A. (1998) Principles and Methods in Landscape Ecology. Chapman & Hall: London.

Forman, R. and Godron, M. (1986) Landscape Ecology. Wiley: New York.

Gobster, P. and Westphal, L. (2004) The human dimensions of urban greenways: planning for recreation and related experiences. Landscape and Urban Planning 68: 289–303.

Hopkins, L. (2002) IUCN and Mediterranean Islands: Opportunities for Biodiversity Conservation and Sustainable Use. IUCN: Gland and Cambridge.

Jongman, R. and Pungetti, G. (eds.) (2004) Ecological Networks and Greenways: Concepts, Design, Implementation. Cambridge University Press: Cambridge.

Kim, K. and Weaver, R. (eds.) (1994) Biodiversity and Landscapes: A Paradox of Humanity. Cambridge University Press: Cambridge.

Leontidou, L., Gentileschi, M.L., Aru, A. and Pungetti, G. (1997) Urban Expansion and Littoralisation. In P. Mairota, J.B. Thornes and N. Geeson (eds.) Atlas of Mediterranean Environments in Europe. Wiley: Chichester, UK, pp. 92–97.

López, A. and Correas, E. (2003) Assessment and Opportunities of Mediterranean Networks and Action Plans for the Management of Protected Areas. IUCN: Gland and Cambridge.
Lovejoy, T.E. and Hannah, L. (eds.) (2004) Climate Change and Biodiversity. Yale University Press: Yale.
Makhzoumi, J. (1996) The spatial and ecological diversity of rural landscapes as a foundation for regional planning. In I. Simpson and P. Dennis (eds.) The Spatial Dynamics of Biodiversity. Proceedings of the 5th annual IALE (UK) Conference, Stirling. Colin Cross Printers: Garstang, UK, pp. 131–138.
Makhzoumi, J. (1997) The changing role of rural landscapes: olive and carob multi-use tree plantations in the semiarid Mediterranean. Landscape and Urban Planning 37: 115–122.
Makhzoumi, J. (2000) Landscape ecology as a foundation for landscape architecture: applications in Malta. Landscape and Urban Planning 20: 167–177.
Makhzoumi, J. (2001) Olive Trees: Inventory and Assessment. Survey prepared for ProAction, North Cyprus, in collaboration with Middle East Environmental Ltd (unpublished).
Makhzoumi, J. (2003) Ebel-es-Saqi Ecological Park: Landscape Assessment and Development. UN-EASCWA, Beirut (unpublished).
Makhzoumi, J. (2005) A Holistic Landscape Approach to Biodiversity Use in Lebanon: Partnering with Landowners. IBSAR-AUB: Beirut (unpublished).
Makhzoumi, J. and Gunduz, S. (2002) Nature conservation in the Mediterranean: new roles for traditional rural landscapes. In H. Gokcekus (ed.) Environmental Problems of the Mediterranean Region. Conference proceedings 12–15 April 2002, Nicosia, Near East University, Nicosia.
Makhzoumi, J. and Pungetti, G. (1999) Ecological Landscape Design and Planning: The Mediterranean context. E & FN Spon: London.
MEDALUS (1993) Mediterranean Desertification and Land Use: Executive Summary. Commission of the European Communities, Directorate General Science and Development, Brussels.
Myers, N. and Cowling, R. (1999) Mediterranean Basin. In R.A. Mittermeier, N. Myers and C. Goettsch Mittermeier (eds.) Hotspots: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions. CEMEX and Conservation International, Mexico City, pp. 254–267.
Naveh, Z. (1990) Ancient man's impact on the Mediterranean landscape in Israel: ecological evolutionary perspectives. In S. Bottema, G. Entjes-Nieborg and W. van Zeist (eds.) Man's Role in the Shaping of the Eastern Mediterranean Landscape. A.A. Balkema: Rotterdam.
Naveh, Z. (1995) Interactions of landscapes and cultures. Landscape and Urban Planning 32: 43–54.
Naveh, Z. (1998) From biodiversity to ecodiversity: holistic conservation of the biological and cultural diversity of Mediterranean landscapes. In P. Rundel, G. Montenegro and F. Jaksic (eds.) Landscape Disturbance and Biodiversity in Mediterranean-type Ecosystems. Springer: Berlin.
Naveh, Z. and Lieberman, A. (1990) Landscape Ecology. Springer: New York.
Polunin, O. and Huxley, A. (1987) Flowers of the Mediterranean. Chatto & Windus: London.
Pungetti, G. (1995) Anthropological approach to agricultural landscape history in Sardinia. Landscape and Urban Planning 31: 41–56.
Pungetti, G. (1996a) Biodiversity and sustainable land use in the Mediterranean. In Ministry of Environment International Symposium on Mediterranean Biodiversity. ENEA: Rome, pp. 107–111.
Pungetti, G. (1996b) Landscape in Sardinia: History Feature Policies. CUEC: Cagliari.
Pungetti, G. (1999) State of the art information on ecological networks in Europe and Italy. In A. Farina (ed.) Perspectives in Ecology: A glance from the VII International Congress of Ecology (INTECOL). Backhuys Publishers: Leiden, pp. 445–452.
Pungetti, G. (2001a) The link between local communities and scientific experts in the framework of regional planning questions in Italy. In Council of Europe, The Partnership of Local and Regional Authorities in the Conservation of Biological and Landscape Diversity. Council of Europe: Strasbourg, pp. 119–125.
Pungetti, G. (2001b) Rio S. Lucia Lowland, Sardinia. In B. Green and W. Vos (eds.) Threatened Landscapes: Conserving Cultural Environments. E & FN Spon: London, p. 87.

Pungetti, G. (2001c) European partnership in ecological networks. In U. Mander, A. Printsmann and H. Palang (eds.) Development of European Landscapes. Publ. Inst. Geographici Universitatis Tartunensis, pp. 567–573.
Pungetti, G. (2003) Ecological landscape design, planning and connectivity in the Mediterranean and in Italy. In M.R.G. Mora (ed.) Environmental Connectivity: Protected Areas in the Mediterranean Basin. Junta de Andalucia, RENPA and IUCN: Sevilla, pp. 109–120.
Pungetti, G. (2005) Ecological networks and ecoregions: new landscape linkages at regional level. In D. McCollin and J.I. Jackson (eds.) Planning, People and Practice: The landscape Ecology of Sustainable Landscapes. IALE-UK, Garstang, pp. 133–139.
Pungetti, G. and Romano, B. (2004) Planning the future landscape in between nature and culture. In R.H.G. Jongman and G. Pungetti (eds.) Ecological Networks and Greenways: Concept, Design, Implementation. Cambridge University Press: Cambridge, pp. 107–127.
Pungetti, G. and Sluis van der, T. (2002) Ecological corridors, scenario and Life. In D. Chamberlain and A. Wilson (eds.) Avian Landscape Ecology: Pure and Applied Issues in the Large-scale Ecology of Birds. IALE-UK: Garstang, UK, pp. 260–263.
Raven, P. (1973) The evolution of Mediterranean flora. In F. di Castri and H. Mooney (eds.) Mediterranean Type Ecosystems. Origin and Structure. Chapman & Hall: London. pp. 213–224.
Rundel, P., Montenegro, G. and Jaksic, F. (eds.) (1998) Landscape Disturbance and Biodiversity in Mediterranean-type Ecosystems. Springer: Berlin.
Thirgood, J. (1987) Cyprus: A Chronicle of Its Forest, Land and People. University of British Colombia Press: Vancouver, Canada.
Troll, C. (1971) Landscape ecology (geo-ecology) and bio-ecology: a terminology study. Geoforum 8: 43–46.
UNEP (2005) Mediterranean Strategy for Sustainable Development: A framework for Environmental Sustainability and Shared Prosperity. UNEP/MAB: Athens.
Wilson, E. (1992) The Diversity of Life. The Belknap Press of Harvard University: Cambridge, MA.
Zonneveld, I. and Forman, R. (eds.) (1990) Changing Landscapes: An Ecological Perspective. Springer: New York.

Chapter 15
Conclusions

I.N. Vogiatzakis[1], A.M. Mannion[2], and G. Pungetti[3]

Pan di Zucchero islet, off the south west coast of Sardinia

15.1 Introduction

The Mediterranean Basin is often considered to be a uniform entity ecologically and culturally. However, any examination at the local level reveals one of the most diverse ecologically, politically and culturally areas in the world. The Mediterranean islands are just such examples of this diversification and complexity (Fig. 15.1).

[1]Centre for Agri-Environmental Research, University of Reading, UK

[2]Department of Geography, University of Reading, UK

[3]Cambridge Centre for Landscape and People and University of Cambridge, UK

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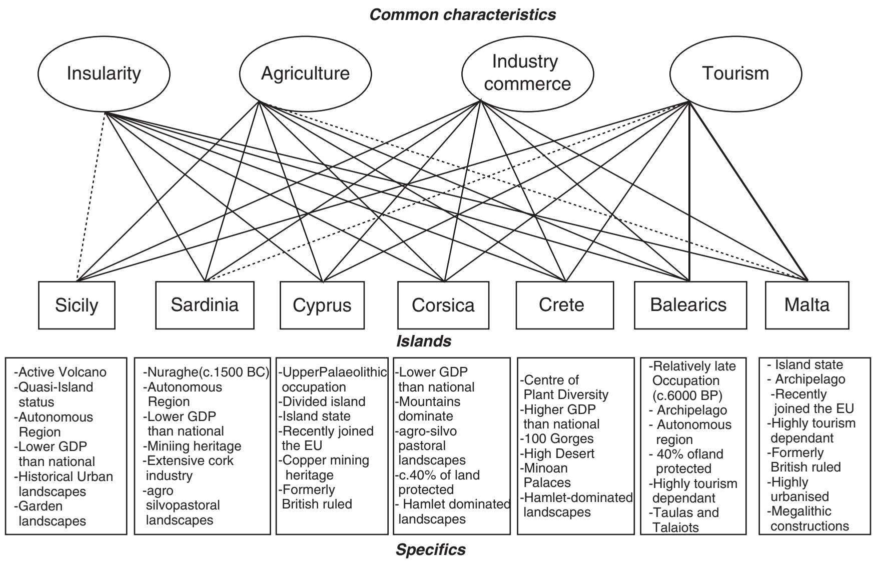

Fig. 15.1 Common characteristics and islands specifics of the Mediterranean Islands examined in this volume. The thickness of the lines indicates the strength of the link

The islands are truly microcosms of the larger entity of which they are part, and are in addition laboratories of biological and cultural processes in evolution. In geological time natural forces set the scene, but since the early Holocene onwards, another force *majeure* that of an intensifying human presence, has influenced geological, biological and climatic forces to shape the landscapes in evidence today. These natural and cultural forces operate at different temporal and spatial scales. However, disentangling the roles of the various components is almost impossible, as demonstrated by the Mediterranean Island landscapes examined in this volume.

Sediment formation, tectonic activity, plate movements and climatic change have all been significant in the geological history of the Mediterranean basin which came into existence c.65 million years ago as a remnant of the great Tethys Ocean. Amongst the most formative events since then was the Messinian salinity event c.6 million years ago when the connection between the Mediterranean Sea and the Atlantic Ocean via the Strait of Gibraltar was closed. This was followed by a period of tectonic activity which gave the basin its topographic characteristics which are the basis for today's landscapes. This period of isolation lasted c.600,000 years until the link with the Atlantic Ocean was reinstated.

Subsequently, climatic instability set in culminating in the major climatic changes of the Tertiary/Quaternary period, that is, last 2–3 million years. Although this is a short time in relation to the overall geological history of the region the repeated cycles of warming and cooling resulted in substantial changes in ecosystem components, not least the flora and fauna and soil processes, rates and types of erosion, drainage patterns and sea level change with implications for land bridges between islands and between islands and the mainland and not least for landscape characteristics. In Corsica and Sardinia, actual glaciation occurred constituting a major force on landscape development. Following global warming as the last cold stage ended and the Holocene (postglacial) opened, ecosystem characteristics changed relatively rapidly with shifts from open vegetation communities to tree- and shrub-dominated communities with subsequent changes in tree/shrub composition. An overwhelmingly important development on all the Mediterranean Islands discussed in this book is the arrival of humans during the Holocene. While the dates so far established for the 'first' inhabitants (see Chapter 1; Table 1.4) vary between islands, evidence suggests that all were colonized between 12,000 and c.7,000 years before present. Thus a new agent of environmental change was introduced which brought the technology of agriculture, associated land clearance involving deforestation, and the beginning of urbanization.

The impact of geological forces on Mediterranean landscapes has been considerable and yet, despite such intensity, there is little comparison with the intensity of human impact which has been dominant for so few millennia. Settlement, agriculture, conflict, invasion, and culture have all influenced Mediterranean landscapes in past millennia and they undoubtedly continue to exert a considerable influence. However, there are additional factors, notably products of the post–World War II era, which include limited industrialization, population increase and immigration, and not least the burgeoning tourist industry in all its forms and pressures.

15.2 Biogeography

The differences in size, isolation, geology and human colonization history have produced highly diverse landscapes that host rich biodiversity that requires protection. The need for increased protection is due to the amplification of problems found as well in the mainland, and therefore increased vulnerability. Small islands and coastal habitats are seen as priorities within the Mediterranean Islands (Greuter 2001) while recent concern over climate change has resulted in emphasis placed on the protection prediction of mountainous areas (Kazakis et al. 2007). The development of systematic conservation plans is usually linked with three main constraints (Cowling and Pressey 2003): an unrepresentative reserve system, escalating threats to biodiversity and inadequate capacity to manage biodiversity. All three constraints are common in the Mediterranean islands. The EU Natura 2000 network has met with criticisms while present and future threats are happening in a faster rate and larger scale. In addition, lack or resources impedes local efforts on biodiversity conservation. Although more recently Mediterranean islands have received some attention (Delanoë et al. 1996; Hopkins 2002; De Montmollin et al. 2005) they have not been subject to any special environmental conservation programmes.

15.3 Cultural Diversity

The Mediterranean islands, like the entire basin, are not just centres of biodiversity, but also centres of cultural diversity. The rise and demise of many civilizations in the Mediterranean have left marks on the landscape. Consequently its character is inextricably linked with cultural heritage and the way people have used the land within the constraints of the island environment. As a result, remarkable cultural landscapes persist today particularly in the Mediterranean islands, reflecting not only their turbulent history, but also the combined action of humans and nature that has transformed the natural wild landscapes to cultural ones. Field boundaries, stone walls, terraces, archaeological sites, churches and monasteries, are distinct features of the Mediterranean Island landscapes. The overlay and sometimes coexistence of these different historical and cultural layers on the landscape leads to emerging patterns which are complex and often difficult to explain. The diversity of rural activities and ancient techniques of agriculture have proven to be in the past beneficial to resources and the environment, resulting in a versatile and stable landscape (Pungetti 1995; Makhzoumi and Pungetti 1999). However, in the last 50 years socio-economic changes as discussed later in this chapter threaten islands' resources and cultural identities, while the international efforts on cultural landscape protection are not always accompanied by similar efforts at the national and regional level, where often there is a lack of specific landscape policies.

15.4 Political Issues

Insularity implies a priori limitation on principal resources such as land, water and soil and these are central themes to the past and future development of the islands. In addition, the high dependence of islands on outside sources and the effect of globalization and trade liberalization on their own resources increase their economic fragility (MEA 2005). As a response, Mediterranean Islands join regional or international groupings in order to address these common issues. Unquestionably, the islands of the Mediterranean which are part of the member states of the EU have better resources, quality of information and stricter enforcement of conservation legislation than those outside the EU. Nevertheless the effectiveness of such agglomerations is questioned (MEA 2005) and increased pressure is directed, particularly towards the EU, for funding and for a greater degree of freedom for the management of island individualities (EURISLES 2002). Despite the limited resources, islands provide a range of ecosystem services including biodiversity, fisheries, energy, fresh water, vegetation cover, traditional ecological knowledge and tourism (MEA 2005). In insular environments the linkage between island ecosystem services and people is stronger and therefore the consequences of breaking those linkages are more serious than continental areas.

15.5 Island Summary

Every island is influenced in a way by a range of constraints, the degree of which vary depending on a series of political, socio-economic and cultural processes within but mainly beyond the island's boundaries. All the Mediterranean Islands discussed herein are the same in the following ways:

- The condition of insularity is the single over-riding influence on ecological and socio-economic characteristics.
- Biodiversity is high with relatively large numbers of endemic species.
- There is substantial human impact.
- Agriculture and tourism have been the major sources of income in the 20th and 21st centuries.
- Tourism is increasing but is subject to major swings, due to accidental air crashes and terrorism, which means that employment, incomes and tax revenues are variable.
- The future is uncertain due to climatic change, especially global warming, and its impact on water availability for ecosystems, agricultural systems and tourist support.
- There is a limited range of options for sustainable development.
- Membership of the EU, with the last members of Malta and Cyprus joining in 2004; this means that from 2004 all the islands discussed herein are subject to EU laws/regulations regarding environmental protection, conservation, agriculture, etc.

Nevertheless, the Mediterranean Islands discussed herein are different in the following ways:

- The degree of insularity is and has varied; Sicily is today very close to Italy and they were joined during the early Holocene when Sicily was also joined to Malta; Sardinia and Corsica were once joined until c.10,000–8,000 years; the Balearics have been islands for millions of years.
- The influences on the biota of the islands have been dominated by proximity to mainland floras and faunas. Since these have been derived from three continents, the distance from each continent has been a significant factor in ecosystem composition.
- Island size varies; larger islands such as Sicily, Corsica and Sardinia have more resources than smaller islands like Malta and Balearics. The disadvantages of insularity in terms of resource limitations are tempered by size.
- Topography is varied; altitudinal variations are most pronounced in Corsica, Sicily and Crete while Malta and the Balearics are relatively low lying.
- Colonization by humans has occurred at different times and all islands have been subject during historical times to invasions from mainland powers at different times; each invasion has wrought innovations which have contributed a cultural dimension to the multifaceted landscapes of each island.

- Varied political/administrative influence prior to EU accession in respect of landscape management/conservation and its enforcement. In some islands poaching and hunting continue uncontrolled despite legislation.
- Agriculture is more important in some islands than in others.
- The degree (i.e. intensity) of influence of EU policy, e.g. on agriculture and tourism, has varied due to different accession dates.
- Advent/expansion of tourism reflects government, often mainland, decisions and varied dates; Malta began its tourism drive in the 1960s but for Corsica and Sardinia the growth in tourism has occurred since 1985.
- There are huge variations in tourist numbers in relation to local population, for example, Malta receives c.1.3 million tourists annually which is equivalent to almost 300% of the island's population while Sicily receives c.2.5 million tourists annually which is equivalent to c.50% of its population.

15.6 Drivers of Change

The evidence in this book suggests that overall there have been significant changes in the last 50 years in the Mediterranean Islands (Table 15.1). In some places these changes are continuation of processes that have started much earlier, while in other are fairly recent. As demonstrated herein, the pressure of an activity-driver is a function of its spatial distribution; certainly tourism affects the coastal areas of the islands more than the hinterland. Even so, there are significant variations. For example, tourism in Crete is mainly confined to the north of the island, while in Sardinia tourism is unknown in some parts. In addition, grazing pressure has been limited in extent in Crete where fewer areas are now grazed more intensively.

Table 15.1 Changes in Mediterranean Island landscapes

Landscape changes (adapted from Heywood 1999)	Drivers of change (MEA 2005)
Changes in agriculture towards large scale operations	Population issues
Merging of farms into larger units	Energy issues
Loss of boundaries with a consequent loss of biodiversity	Invasive alien species
Abandonment of terracing	Habitat Loss, Pollution and Land Degradation
Movement away from the land to the towns and cities	Economic changes
Crop substitution in terms of individual crops or whole agroecosystems	Short-term disturbances and natural events
Introduction of new crops and intensive commercial horticulture	Climate change and sea level rise
Alien and invasive species	
Effects of agricultural, industrial and urban pollution	
Genetic resources erosion, pollution	

Changes are part of the landscape dynamics (Grove and Rackham 2001; Mazzoleni et al. 2004). A pattern emerging from this book is that in many island areas change has been in favour of semi-natural vegetation (Chapter 11). The figures on land-use change (Chapter 6; Fig. 6.2) shows a consistent increase in wooded areas in four out of the seven islands-island groups examined in this book. Abandonment, furthermore, emerges as a common issue, threatening traditional landscapes in the majority of the islands. Nevertheless, there have been areas that have seen little change in that period such as the Iblei mountains of Sicily (Di Pasquale et al. 2004) or central Psiloritis mountain in Crete (Hill et al. 2004).

The development of tourism coincided in many islands with the restructuring of their economies (McElroy 2003). Tourism growth has taken place at a fast rate in an unplanned and intrusive manner. In highly developed islands such as the Balearics and Malta, consequences of tourism development have affected not only species and habitats, which have rapidly declined, but also insular lifestyles and identity that are now threatened (Lanfant et al. 1995). Alternative forms of tourism could have positive impact to the conservation of cultural heritage and traditional practices, hence shifting the pressure from natural resources and biodiversity (Morey and Martinez-Taberner 2000).

Despite the small contribution of islands to global emissions of greenhouse gasses, it is widely recognized that many islands are likely to be among the communities most adversely affected by climate change (IPCC 2001). Climate is a key defining variable of the physical character of landscape. Therefore changes in climate and associated extreme events are likely to affect directly and indirectly the character of the landscape, both physical and cultural, which in turn may trigger changes in future landscape perception and preference. However, and despite the existing projections, it is still uncertain to what extent climate related changes will take place. Even more uncertain are the precise manifestations at the individual island level, their cumulative effects and human responses. What is needed is an increased effort on national and regional-based assessments.

Apart from climate change, it is almost certain that economic development will be the other key driving force on landscape, including emerging land uses such as biofuel crops and wind farms, resulting in 'new' types of landscape. For example, following the rising in oil prices, the EU is promoring land set aside for biofuel crops. In addition, wind farms have already made their appearance in larger islands such as Sardinia and Crete.

15.7 Islands and the Future

Insularity, although a physical property, is clearly aggravated by socioeconomic, political and cultural isolation. Therefore, Mediterranean islands suffer from similar constraints and face similar sustainable development challenges. Resource restrictions lead to the question on how to manage island resources effectively. Maximizing production, that is, focusing on a single activity such as

Table 15.2 Blue plan development scenarios for the Mediterranean Island (Brigand 1991)

Scenarios	Trends	Results/Impacts
Aggravated Trend	Current Trends continue and increase	– Increased demographic and socio-economic imbalance – Smaller and 'isolated' islands mostly affected – Ecosystem Protection limited to few areas on tourist-attractive islands
Moderate Trend	Faster development caused by a significant upswing in economic growth	– Promote regional inequalities reinforced by tourist flows – Increased dependence on continent – Increased specialization broadens between island gaps – Limited environmental protection
Alternative	Sustainable development models	– Inclusion and economic valuation of (all) local resources – Long-term development planning respectful to landscapes – Increased exchange/collaboration between islands (island regionalization) – Fair and harmonious relationships with continent

agriculture, is not a feasible option since the size of an island will not allow competition with any continental area. Occupational diversification is a practice employed in historic times in order to exploit the limited opportunities that the island realm provides (Royle 2001). Under the UNEP Blue Plan for the environment and development of the Mediterranean (Benoit and Comeau 2005), there has been a separate evaluation of three different scenarios for the development of the Mediterranean islands (Brigand 1991) the main points of which are shown in Table 15.2. Moreover, the Island Commission of the Conference of the Peripheral and Maritime Regions (CPRM) advocates the rethinking of the island policy for the EU islands, based on the principles of permanence, positive differentiation and proportionality (EURISLES 2002). The proposed islands policy consist of a series of socio-economic and environmental goals which aim to minimize island vulnerability, and level off the differences between islands and their mainland (Fig. 15.2).

The spatial framework that can be employed for delivering any suggested policies is as important as the policies themselves. During the last 20 years there has been recognition that a landscape scale approach is fundamental to the understanding of ecological and cultural processes. The landscape scale is considered to be the appropriate spatial framework for the analysis of sustainability. As a result, landscape approaches have been adopted by international and national organizations to summarize pressures and threats, and to develop policies for sustainability. For example, landscape conservation has been long advocated by IUCN (1994) with

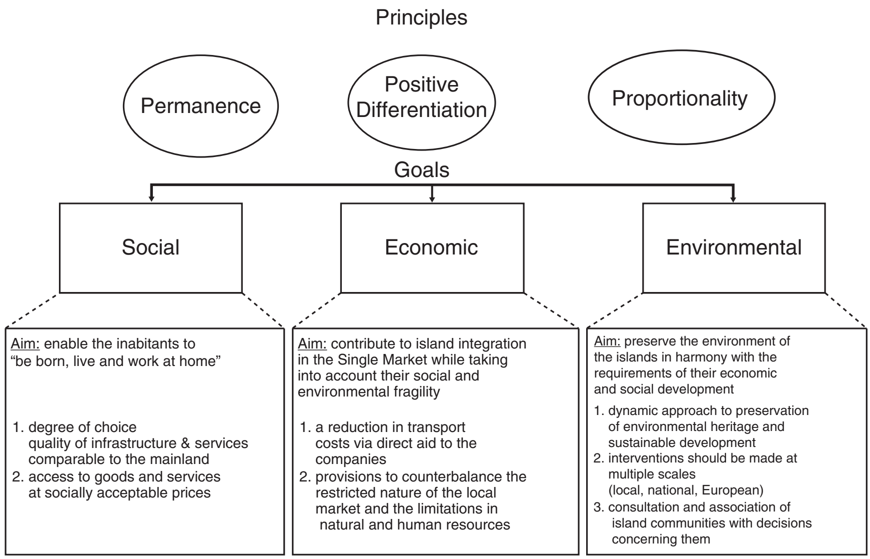

Fig. 15.2 Principles and goals of a development Policy for EU Islands (EURISLES 2002)

the designation of category V for protected areas. At the same time, a paradigm shift in biodiversity conservation highlights the importance of landscape and the need for an all-inclusive approach (Heywood 1995, 1999). The IUCN recognizes that (Hopkins 2002):

> In connection with the long history of agricultural land use in Mediterranean islands and IUCN's search for holistic approaches to conservation and sustainable use, exploration of a landscape approach to island conservation may pay dividends, especially as it is likely to make a link with tourism.

Landscape as defined by Forman and Gordon (1986) is a mosaic of 'interacting ecosystems'. The term has many components including visual, political, socio-economic and cultural, as also pointed out by the European Landscape Convention (Council of Europe 2000). Therefore, the broad concept of *landscape*, encompasses both natural and cultural elements, i.e. the natural landscape is the fabric that integrates settlement, agriculture and ecology. A holistic landscape approach (Pungetti 1999) as advocated in Chapter 14, promotes the study of processes and relationships and their links within the landscape, while at the same time builds bridges between ecology and culture, past and present, experts and stakeholders. Hence this approach enables a more sound protection and management of the island landscapes.

The contributions in this book have provided evidence about an ongoing increase of human impacts on Mediterranean Island landscapes. There are many ways of describing human impacts quantitatively in the form of indices. Usually these indices are only available at the state level, and therefore in the case of Mediterranean

Islands are applicable only to Malta and Cyprus. One example receiving a great deal of attention in the last 4 years is the Environmental Sustainability Index (ESI), which was first published in 2001 and subsequently in 2002 and 2005 (Morse and Fraser 2005). This is an aggregation process from ‘variables’ (raw data sets) combined into ‘indicators’ which in turn are placed into one of five ‘components’ and then averaged to generate the ESI. Another index, the Ecological footprint index, calculates how much productive land and sea is needed to feed humans and provide all the energy, water and materials they use in everyday life (Chambers et al. 2000). A new global measure of progress, the Happy Planet Index, measures the environmental cost with which countries deliver lives of different length and happiness (Marks et al. 2006). According to this index, island nations score well above the average; Malta tops the Western world with Cyprus in seventh place, out of 24. More recently the use of a carbon index has also been proposed by Mannion (2006) as a useful tool for environmental management.

While describing changes in the landscape is important, equally important is the ways in which these changes can be predicted and accounted for in the planning process. Therefore, a question to be addressed in landscape planning is how a landscape can accommodate change. Two fundamental concepts linked to this question are landscape sensitivity and capacity. Landscape sensitivity, be it ecological, cultural or perceptual, is the ability of a landscape to accommodate change or development while capacity refers to the amount of this change (Swanwick 2004). A future challenge, accordingly, is to develop ways to measure the different components of sensitivity, as well as tools to respond to different spatial scales of change within a landscape. Moreover, there is the need to design a multifunctional landscape which will accommodate diverse, often conflicting, activities such as conservation, recreation and agriculture.

15.8 Conclusion

Being one of the oldest inhabited areas of the world, the Mediterranean Basin has acquired a distinct cultural and political diversity. This clearly contrasts with regions of mediterranean-type climate elsewhere, which are as diverse naturally but relatively uniform culturally and socio-economically since they occur in single countries. In the Mediterranean Basin the superimposition of cultural and socio-economic complexity on a diverse array of natural landscapes, amplifies the challenge of landscape management especially in island settings. Globally the only truly common characteristic apposite to islands is their insularity; it is island-specific natural and cultural characteristics which impart uniqueness, as is evident for the Mediterranean Islands discussed in this book.

The information presented herein has allowed the formulation of some general conclusions in relation to past and present landscape change. It has confirmed the multifaceted character and worldwide significance of the Mediterranean

Islands and highlighted the challenges to sustainable development which must be addressed. Inherently vulnerable to naturally and culturally driven landscape change, the character, condition and integrity of the Mediterranean Islands have been threatened by the anthropogenic impacts of the last 60 years. Consequently, policies and measures capable of accommodating the dynamism of these islands are urgently needed to ensure a sustainable future.

References

Benoit, G. and Comeau, A. (2005) A Sustainable Future for the Mediterranean: The Blue Plan's Environment and Development Outlook. Earthscan: London

Brigand L. (1991) Les îles en Méditerranée: Enjeux et perspectives. Economica - PlanBleu

Chambers, N., Simmons, C. and Wackernagel, M. (2000) Sharing Nature's Interest: Ecological Footprints as an Indicator of Sustainability. Earthscan: London.

Council of Europe (2000). European Landscape Convention. Florence. European Treaty Series – No 176.

Cowling, R.M. and Pressey, R.L. (2003) Introduction to systematic conservation planning in the Cape Floristic Region. Biological Conservation 112, 1–13.

De Montmollin, B. and Strahm, W. (eds.) (2005) The Top 50 Mediterranean Island Plants IUCN/SSC Mediterranean Islands Plant Specialist Group

Delanoë, O., Montmollin de, B. and Olivier, L. (1996) Conservation of the Mediterranean Island Plants. 1. Strategy for Action. IUCN: Cambridge.

Di Pasquale, G., Garfi, G. and Migliozzi, A. (2004) Landscape Dynamics in South-Eastern Sicily in the last 150 years: the case of the Iblei Mountains. In S. Mazzoleni, G. di Pasquale, M. Mulligan, P. di Martino and F. Rego (eds.) Recent Dynamics of the Mediterranean Vegetation and Landscape. Wiley: Chichester, UK, pp. 73–80.

EURISLES (2002) Off the coast of Europe: European construction and the problem of the islands. Report for the Islands Commission of the Conference of the Peripheral and Maritime Regions (CPMR). 150 pp.

Forman, R.T.T. and Godron M. (1986) Landscape Ecology. Wiley: New York.

Greuter, W. (2001) Diversity of Mediterranean Island Floras. Bocconea 13: 55–64

Grove, A.T. and Rackham, O. (2001) The Nature of the Mediterranean Europe. Yale University Press: New Haven.

Heywood, V.H. (1995) The Mediterranean flora in the context of world biodiversity. Ecologia Mediterranea 21, 11–18.

Heywood V.H. (1999) The Mediterranean Region: A major centre of plant diversity. Cahiers Options Méditerranéennes 38, 1–15.

Hill, J., Hostert, P. and Roder, A. (2004) Long-term observations of Mediterranean ecosystems with satellite remote sensing. In S.Mazzoleni, G. di Pasquale, M. Mulligan, P. di Martino and F. Rego (eds.) Recent Dynamics of the Mediterranean Vegetation and Landscape. Wiley: Chichester, pp. 33–43.

Hopkins, L. (2002) IUCN and the Mediterranean Islands: Opportunities for Biodiversity Conservation and Sustainable Use. IUCN.

IPCC (International Panel on Climatic Change) (2001) Climate Change 2001: Impacts Adaptation and Vulnerability. Cambridge University Press: Cambridge.

IUCN (1994) Guidelines for Protected Area Management Categories. CNPPA with the Assistance of WCMC. IUCN, Gland: Switzerland and Cambridge.

Kazakis, G., Ghosn, D., Vogiatzakis, I.N. and Papanastasis V.P. (2007) Vascular plant diversity and climate change in the alpine zone of the Lefka Ori, Crete. Biodiversity and Conservation 16, 1603–1615.

Lanfant, M.F., Allcock, J.B. and Bruner, E.M. (1995) International Tourism: Identity and Change. Sage: London.

Makhzoumi, J. and Pungetti, G. (1999) Ecological Landscape Design and Planning: The Mediterranean context. Spon, London.

Mannion, A.M. (2006) Carbon and its Domestication. Springer.

Marks, N., Simms, A., Thompson, S. and Abdallah, S. (2006) The (un) Happy Planet Index: an index of human well-being and environmental impact. New Economic Foundation.

Mazzoleni, S., di Pasquale, G., Mulligan, M., di Martino P. and Rego, F. (eds.) (2004) Recent Dynamics of the Mediterranean Vegetation and Landscape. Wiley: Chichester, UK, 306 pp.

McElroy J.L. (2003) Tourism development in small islands across the world. Geografiska Annaler 85B, 231–242.

MEA (Millennium Ecosystem Assessment) (2005) Ecosystems and Human Well-being: Current State and Trends. Millennium Ecosystem Assessment Series. Island Press.

Morey M. and Martinez-Taberner A. (2000) Environmental conservancy strategies in the Mediterranean Islands. In L. Trabaud (ed.) Life and Environment in the Mediterranean. WIT Press, pp. 345–386.

Morse, S. and Fraser, E.D.G. (2005) Making 'dirty' nations look clean? The nation state and the problem of selecting and weighing indices as tools for measuring progress towards sustainability. Geoforum 36, 625–640.

Pungetti, G. (1995) Anthropological approach to agricultural landscape history in Sardinia. Landscape and Urban Planning 31 47–56.

Pungetti, G. (1999) A holistic approach to landscape research in the Mediterranean. In J. Makhzoumi and G. Pungetti (eds.) Ecological Landscape Design and Planning: The Mediterranean context. E & FN Spon: London, pp. 34–43.

Royle, S. (2001) A Geography of Islands: Small Island Insularity. Routledge.

Swanwick, C. (2004) Topic paper 6: Techniques and criteria for judging capacity and sensitivity. Countryside Agency and Scottish Natural Heritage on the Countryside Character Network (CCN). www.ccnetwork.org.uk (last accessed 5 December 2006).

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