1
Introduction to the Mediterranean mountain environments

Ioannis N. Vogiatzakis

1.1 Introduction

Mountains are present in all continents, latitude zones and principal biome types, accounting for more than 20% of the Earth’s terrestrial surface (Beniston, 2000). They come in all shapes and forms and are even present on islands, oceanic and continental. The northern hemisphere hosts most of the world’s mountain areas, whereas the highest concentration of high mountains is in Central and southern Asia. The harsh conditions of mountain environments, including high altitude steep slopes, and extreme weather, result in them being regarded as hostile regions and therefore less inhabited and productive areas. However, they are still home to 20% (1.2 billion) of the world’s human population and have special spiritual, cultural and sacred significance for over one billion people worldwide (Price, 2004). Isolation in geological and historic times has resulted in mountains acting as biological and cultural laboratories.

Worldwide mountains encompass a great diversity of topographic, climatic, biotic and cultural elements and therefore provide a range of ecosystem services (MEA, 2005).

Mountains are an important source of water, energy and biological diversity. Furthermore, they are a source of such key resources as minerals, forest products and agricultural products and of recreation. As a major ecosystem representing the complex and interrelated ecology of our planet, mountain environments are essential to the survival of the global ecosystem.

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Half of the human population depends on mountains, while globally about half of the mountain area is under some sort of human land use (Körner and Ohsawa, 2005). Despite the harsh environmental conditions, human presence in mountain areas has a long history, going back millennia for some parts of the world such as the Mediterranean Basin. The wealth of goods and services that mountains provide come at an extra cost for human communities due to the limitations on the exploitation of these resources compared to other environments. The major environmental issues that mountains face worldwide include, other than dynamic geophysical processes (e.g. North Atlantic Oscillation and volcanic activity), anthropogenic ones such as pollution, land use change and human-induced climatic change (Beniston, 2000). A recognition of mountains in the policy agenda came in 1992 at the UN Conference on Environment and Development, which resulted in the establishment of other initiatives – Mountain Partnership, Mountain Forum: Glochamore (Global Change in Mountain Regions) – and received the attention of the Intergovernmental Panel on Climate Change, the Convention on Biological Diversity and the Millennium Ecosystem Assessment (Price, 2007). These are attempts to outline the scientific challenges (i.e. threats and opportunities) that the mountains face worldwide for future development (Table 1.1). Globally there are many drivers that affect

<table>
<thead>
<tr>
<th>Topic</th>
<th>Research goal</th>
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<tbody>
<tr>
<td>Climate</td>
<td>To develop consistent and comparable regional climate scenarios for mountain regions, with a focus on Mountain Biosphere Reserves</td>
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<tr>
<td>Land use change</td>
<td>To monitor land use change in mountain regions using methods that are consistent and comparable</td>
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<td>Cryosphere</td>
<td>To predict the areal extent of glaciers under different climate scenarios</td>
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<td>Water systems</td>
<td>To determine and predict water balance and its components, particularly run-off and water yield of mountain catchments (including wetlands and glaciers) under different global change scenarios</td>
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<tr>
<td>Ecosystem functions and services</td>
<td>To predict the amount of carbon and the potential yield of timber and fuel sequestered in forests under different climate and land use scenarios</td>
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<td>Biodiversity</td>
<td>To assess current biodiversity and to assess biodiversity changes</td>
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<td>Hazards</td>
<td>To predict changes of lake systems and incidence of extreme flows in terms of frequencies and amounts, under different climate and land use scenarios</td>
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<td>Health</td>
<td>To understand the current and future distribution and intensity of climate-sensitive health determinants, and predict outcomes that affect human and animal health in mountain regions</td>
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<td>Mountain economies</td>
<td>To assess the value of mountain ecosystem services and how that value is affected by different forms of management</td>
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<tr>
<td>Society and global change</td>
<td>To understand the environmental, economic, and demographic processes linking rural and urban areas in mountain regions, as well as those leading to urbanization, peri-urbanization and metropolization</td>
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</table>
1.2 SETTING THE SCENE

environmental change although at present the principal ones are climate, land use change, and their interactions. In a mountain environment context, environmental change will affect the capacity of landscapes to continue to provide services not only for resident populations but also for dependent populations beyond the mountains’ extent. Changes in temperature and precipitation regimes, and the frequency of extreme events, will have severe repercussions on the physical character and on the biological and human communities of mountain areas. Glaciers, snow cover, water storage and flow, are unique features of mountainous areas; however, any changes affecting them will in turn impact on lowland areas. The range of environmental conditions present in mountain regions has resulted in mountains playing a significant part in the conservation of global biodiversity. Environmental changes will affect not only the species present, but also ecosystem functions such as biochemical cycling and habitat provision. Climate changes, through the alteration of the frequency of extreme events, may pose a threat to life and property in mountain regions, create new health hazards for humans and their domestic animals, and cause severe impacts on mountain economies and livelihoods. Land use, one of the major drivers of change globally, is subject to external forces such as climate and global markets. The response to change will not only require increased understanding of how drivers operate in mountain environments but also the appropriate institutional capacities to react.

Although many textbooks and specialized books have been written about mountain environments (e.g. Gerrard, 1990; Barry, 1992; Funnell and Parish, 2001; Parish, 2002) there has been only one so far for the Mediterranean mountains (McNeill, 1992). This first chapter is an introduction to the mountain environments of the Mediterranean Basin. It will set the scene and place the mountains of the basin in the global context while at the same time providing a brief overview of the various subjects illustrated in this book, and explain the organization of its content.

1.2 Setting the scene

Unquestionably mountains constitute the backbone of the whole Mediterranean region, including the largest islands in the basin (Figure 1.1). McNeill (1992, p. 1) in the only book dedicated to the Mediterranean mountains to be published so far, wrote: ‘The beauty of the Mediterranean mountains is in way a sad one. Skeletal mountains and shell villages dot the upland areas of the Mediterranean world, dominating the physical and social landscape.’ Imposing massifs run from North to South such as the Pindos in Greece, the Apennines in Italy, and the Dinarids in Balkans, West to East such as the Atlas Mountains extending over 3500 km from North Morocco to Tunisia, and dominate the landscapes of Sicily, Sardinia, Corsica, Cyprus and Crete.

Definitions about what constitutes a mountain vary and include topography, climate, vegetation, constraints on agriculture, or length of growing seasons (Gerrard, 1990; Kapos, 2000). A working definition is the one by Price (1981): ‘An elevated landform of high local relief, e.g. 300 m (1000 ft), with much of its surface in steep
Figure 1.1: Delimitation of the Mediterranean biogeographical area with the major Mediterranean mountains. Reproduced from Blondel et al. (2010), with permission.
1.2 SETTING THE SCENE

Table 1.2 Percentage of mountainous land within Mediterranean countries (Regato and Salman, 2008)

<table>
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<tr>
<th>Mediterranean countries</th>
<th>Percent of mountainous area within a country</th>
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<tbody>
<tr>
<td></td>
<td>0–10</td>
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<tr>
<td>Andorra, Bosnia and Herzegovina, Italy,</td>
<td></td>
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<tr>
<td>Lebanon, Macedonia, Montenegro</td>
<td></td>
</tr>
<tr>
<td>Albania, Greece, Morocco, Serbia, Slovenia,</td>
<td></td>
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<tr>
<td>Turkey, Palestinian Territories</td>
<td></td>
</tr>
<tr>
<td>Croatia, Cyprus, Israel, Portugal, Spain</td>
<td></td>
</tr>
<tr>
<td>Algeria, France, Jordan, Syria, Tunisia</td>
<td></td>
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<tr>
<td>Egypt, Libya, Malta</td>
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slopes, usually displaying distinct variations in climate and associated biological phenomena from its base to its summit.' According to this definition an attempt to answer the question how large is the mountain area globally came up with the figure of 24.3% of total land area. The figure excludes the major plateau areas, and all land area outside Antarctica (Kapos et al., 2000). Mediterranean mountains cover some 1.7 million km$^2$, equivalent to 21% of the combined surface area of all the countries concerned, and are home to 66 million people, representing 16% of the region’s total population. Mountains occupy more than 50% of land in many Mediterranean countries (Table 1.2), seven of which are among the top 20 mountainous countries in the world. Morocco is an example of such country with a high percentage of mountainous land, where four major mountain ranges – the Rif, the Middle Atlas, the High Atlas and the Anti-Atlas – occupy 15% of its territory (Radford et al., 2011).

The delineation of the Mediterranean mountains is a more complex issue since it is directly related to the delineation of the Mediterranean area itself, which has been the topic of debate for decades. For the latter the criteria used have been floristic, climatic or bioclimatic (see Blondel et al., 2010). In a recent attempt at an environmental classification for the whole of Europe (Metzger et al., 2005), Mediterranean mountains were recognized as separate entities influenced by both the Mediterranean zone they are situated in, and a distinct mountain climate. The class ‘Mediterranean mountains’ encompasses low and medium mountains in the northern part of the basin and high mountains in the southern part. As Blondel et al. (2010) state, 'there is no satisfactory answer to the question of what is a “Mediterranean mountain”, as compared to a mountain range simply marking a regional boundary.' Taking into account the various delineations and classification schemes applied in the Mediterranean Basin, we broadly distinguish three mountain categories in this book from the heart to the periphery of the basin:

- Mountains at the very heart of the Mediterranean either due to their geographical position or their moderate altitude, including the Sierra Nevada, Cyrenaica, mountains of the Peloponnese and those on the islands of Sicily, Corsica, Crete and Cyprus.
Mountains that are considered outside the influence of, or on the periphery of the Mediterranean, for example the Alps, Mercantour, the North Dinarids, and the North of Anatolia (Ozenda, 1975).

Mountains included in the various delineations of the Mediterranean area that have biotic affinities to the basin, such as the mountains of the Canary islands.

This book focuses on the first category, since extending this volume to cover all the massifs associated with the Mediterranean Basin would be a huge task. However, there are limited references to the other two categories (see Chapters 3 and 4).

Mediterranean mountains exhibit many similarities in their biotic, ecological, physical and environmental characteristics but also significant differences. They have always been inextricably linked to their surroundings, providing, for example, cities and coastal areas with invaluable resources including water, timber and even labour (Benoit and Comeau, 2005). Relief in the Mediterranean is affected more by erosional processes than by glacial abrasion, compared to other European mountains; Mediterranean mountains receive more precipitation compared to the surrounding lowlands and are sources of various important rivers. In general, mountains in the northern part of the Mediterranean are lower than those in the southern Mediterranean. Primary and secondary shrub formations (e.g. maquis, carriga, carrascal, phrygana, shibliak) are very common, with distinct differences between north and south. Floristic composition, and the level and concentration of endemism vary (see Chapter 6). Other differences include human colonization patterns, historic land uses and current anthropogenic pressures. For example, tourist impact is greater in northern than in southern Mediterranean mountains, whereas grazing follows the opposite trend. This book addresses these characteristics and examines the major environmental changes that the mountains experienced during the Quaternary period.

1.3 The character of the Mediterranean mountains

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. The mountains of the Mediterranean have changed significantly since the end of the last ice age c. 12,000 years ago, due to sea-level rise, and in turn the biogeographical characteristics of the mountains have been altered. In Chapter 2, faunal and palynological evidence is examined to provide a picture of the changes in biota and the environment through the Quaternary, with emphasis on changes, including human impacts, during the last 12,000 years.

Many of the Mediterranean mountains supported glaciers during the Pleistocene, and some glaciers and ice patches still survive today, as discussed in Chapter 3. Cirques, U-shaped valleys, arêtes, roches moutonées, glacial lakes and moraines
1.3 THE CHARACTER OF THE MEDITERRANEAN MOUNTAINS

Present today in the mountains of the region are all evidence of these glaciations that have shaped the landscape. Today the majority of the glaciers present are restricted to the highest mountains such as the Pyrenees, the Maritime Alps and the mountains of Turkey. However, several glaciers also exist in lower mountain areas, such as central Italy and in Montenegro and Albania (see Chapter 3).

The presence of a ring of mountains around the Mediterranean Basin, with the exception of the southeastern part, is a result of the collision between the African and the Eurasian plates. Some of the mountains, like the Sierra Nevada, are underlain by Archaean structures while others, for example the Maritime Alps, by more recent Miocene deposits. The Atlas, Rif, Baetic Cordillera, Cantabrian Mountains, Pyrenees, Alps, Apennines, Dinaric Alps, Hellenides, and Balkan and Taurus mountains are all products of the alpine orogeny, while the mountains of Portugal and western Spain, as well as Sardinia, are of Hercynian origin. Many of these such as the Sierra Nevada, Etna, Taurus, High Atlas and Mount Lebanon reach over 3000 m while there are several active volcanoes in the area. Chapter 4 provides an overview of tectonic setting and landscape development of the Mediterranean mountains, including the range of geological substrates encountered. Mountains are high-energy environments characterized by great instability and variability. This is well demonstrated in the soils of Mediterranean mountains, where a variety of raw lithomorphic soils, particularly in the high alpine zones, is present.

The altitudinal and continental position as well as latitude and topography of mountains exert an influence on climate (Barry, 1992). Mountain areas worldwide contain the sources of all major rivers, and those of the Mediterranean are no exception. Rivers like the Guadalquivir, Ebro, Rhône and Po have their source/origins on some of the most important mountains in the area, contributing water to dry lowlands. However, climate and hydrology in the Mediterranean mountains receive little attention compared to other mountain massifs worldwide. Chapter 5 provides a comprehensive overview of interaction of the major hydrological and meteorological processes in Mediterranean mountain areas. This overview includes snowmelt, run-off and floods, water fluxes and water balance, hydrometeorological coupling and modelling. It reviews recent research in the field and illustrates key interactions from a range of mountainous regions in the Mediterranean. Emphasis is given to human impacts, assessment of mountain water resources, conservation and water quality.

Due to their altitudinal range, mountains contain a wide range of environments in a short distance and therefore support more habitats than equivalent lowland areas. Although in absolute terms the number of species is smaller compared to lower areas, Mediterranean mountains support florals of special interest. They all contain a high number of endemic species, with southern mountains having a higher percentage of endemism than those in the north. Some endemics are relictual, whereas others are more recent as a result of specific and localized factors such as discrete orogenies and rare substrates. Chapter 6 discusses the mountains’ biogeographical affinities and peculiarities in terms of biota and habitats. Emphasis is given to the distinct altitudinal zonation and the main vegetation types encountered in the
Mediterranean mountains as well as the adaptations of biota to high-altitude environmental conditions. In addition the pressures on mountain biodiversity and the efforts at national and international level for its protection are discussed.

Throughout the Mediterranean Basin, human identities and cultures in mountain areas are diverse both historically and currently. Mountains provide refuge not only to plant and animal species but also to people trying to escape from invaders, and they form a distinctive component of many peoples’ cultural identity. In the interior mountains of each Mediterranean country, human populations are still extraordinarily distinct linguistically and behaviourally (McNeill, 1992). People have always had spiritual connections with and cultural roots in the most imposing massifs of the Mediterranean, while traditional management systems have resulted in cultural landscapes with unique biodiversity, cultural and socioeconomic values. The link between culture and Mediterranean mountain environments is dealt with in Chapter 7.

Environmental and economic change is no stranger to the Mediterranean mountain environments (for the role of natural forces see Chapters 3, 4 and 5). In their quest for timber, fuel and minerals, humans have left their irreversible mark on these mountains. The increasing reliance of human communities on mountains for various services has led to a magnitude and rate of change that threatens to overwhelm mountain ecosystems and hence the communities they support. Currently Mediterranean mountain environments, and the human communities that live and work there, face unprecedented threats from social, economic and environmental forces of change. These same forces also bring exciting opportunities for the integration of knowledge and expertise to achieve sustainable solutions for future development of these areas. The first part of Chapter 8 provides a historical analysis of land uses (grazing, transhumance, terrace cultivations), the drivers (economic, social and environmental) that determine the pattern of change, and how those vary across the Mediterranean mountains. The second part provides a description of the current situation in some of the most mountainous countries in the Mediterranean and discusses the impacts of land use change and future challenges.

Climate change poses a number of potential risks to ecosystems globally. Although the impacts cannot as yet be predicted with certainty, mountain systems are particularly sensitive to changes in climate, supported by past evidence (geological era) of vegetation zone shifts (Beniston, 2000). Mediterranean mountains are under threat from climate change, which affects directly or indirectly different key features, such as biodiversity, snow cover, glaciers, run-off processes and water availability. Chapter 9 reviews recent and future trends in Mediterranean mountain climate. It provides an assessment of temperature, precipitation, and spring precipitation changes in Mediterranean mountains under different emission scenarios and Atmosphere-Ocean-Coupled General Circulation Models. The implications of predicted climate change for both human and physical features and synergies with other pressures on mountain environments are discussed, focusing on the cryosphere, hydrosphere and biodiversity.
REFERENCES

The Mediterranean has been exploited for thousands of years, and some scholars claim that it has proven to be resilient (Grove and Rackham, 2001). Mediterranean mountain landscapes in the past achieved equilibrium among the principal activities (agriculture, pastoralism and forestry), which also promoted environmental protection (see Chapter 8). This is no longer the case, bringing severe consequences for mountain resources. Do the socioeconomic changes of the last 50 years threaten resources and cultural identities? Have we exceeded carrying capacity and can we reconcile development and conservation? What are the challenges and the options for mountain environments and the communities that depend on them. The last chapter of this book (Chapter 10) underlines the differences and similarities of Mediterranean mountains. It provides a synthesis of the challenges that the mountains are facing, as outlined in this chapter and addressed in subsequent relevant chapters, and places those in the light of potential future development. This concluding chapter emphasizes the need to ensure the ecological health and the economic and social improvement of mountain areas through an ecosystem-based approach, which will take into account both the physical environment and the livelihoods of mountain and lowland communities alike.

References

References marked as bold are key references.


