State of Mediterranean Forests 2013

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Preface

Eduardo Rojas-Briales

Assistant Director-General
FAO Forestry Department

Hugues Ravenel

Director of Plan Bleu
MAP/UNEP

Forest ecosystems and other wooded lands are an important component of landscapes in the Mediterranean region, contributing significantly to rural development, poverty alleviation and food security. They are sources of wood, cork, energy, food and incomes, and they provide important ecosystem services such as biodiversity conservation, soil and water protection, recreation and carbon storage. They are crucial for many of the region's economic sectors, such as food supply, agriculture, soil and water conservation, drinking water supply, tourism and energy.

Global changes (changes in societies, lifestyles and climate) strongly affect the Mediterranean region. If unmanaged, such changes could lead to the loss of biodiversity, an increased risk of wildfire, the degradation of watersheds, and desertification, with serious consequences for the sustainable provision of forest goods and ecosystem services.

It is therefore urgent to develop a tool for information and monitoring in order to regularly assess these changes and to communicate based on objective and reliable data with the different stakeholders involved in the management of Mediterranean forest ecosystems. With this in mind, the members of the Committee on Mediterranean Forestry Questions-*Silva Mediterranea* requested FAO, at a meeting held in April 2010 in Antalya, Turkey, to prepare a report on the state of Mediterranean forests.

FAO subsequently drafted terms of reference for the preparation of this first *State of Mediterranean Forests* (SoMF). It was agreed to use already-available data collected by regional and international institutions in the context of other environmental assessment processes, such as the state of the environment and development in the Mediterranean process (Plan Bleu, 2009) and FAO's five-yearly Global Forest Resources Assessment (FAO, 2010).

It was also proposed that the production of the report would be a collaborative effort involving national, regional and international institutions for the writing of several chapters. The proposed approach and structure of the first *State of Mediterranean Forests* was presented and formally approved by member states at the 21st session of the Committee on Mediterranean Forestry Questions-*Silva Mediterranea*, held in Antalya in February 2012.

Under the coordination of Plan Bleu and FAO, scientific institutions (EFIMED in Barcelona, JRC/EFFIS in ISPRA, INRA in Avignon, Centre for Agricultural Research in Arezzo ...), technical institutions (Mediterranean Institute on Cork*, Haut Commissariat aux eaux et forêts et à la lutte contre la désertification, Centre technologic forestal de Catalunya, Office national des forêts* in France and *Corpo Forestale dello Stato* in Italy ...) and non-governmental organizations (Mediterranean Model Forests Network*, Association internationale forêts méditerranéennes,* and the Mediterranean offices of the World Wildlife Fund and the International Union for Conservation of Nature) contributed to this first *State of Mediterranean Forests*.

It was also decided that this first edition of *State of Mediterranean Forests* would be an opportunity to analyze data gaps and suggest improvements for future data collection under the various environmental assessment processes. We are indeed aware that this first edition of *State of Mediterranean Forests* can be improved. For example, the national reports submitted to FAO for the 2010 Global Forest Resources Assessment generally did not capture information specific to Mediterranean forests, which is particularly an issue for countries such as France, Italy and Spain that have large areas of both Mediterranean and non-Mediterranean forests.

We are proud to present this report, the result of three years of hard work by a team at Plan Bleu and the FAO Forestry Department. We would like to thank all the authors and other contributors to this collective document – nearly 50 people and more than 20 institutions around the Mediterranean have been involved in this publication since April 2010.

The strength of the collaborative effort shows that regional cooperation on Mediterranean forests is alive and well. It is intended that further editions of *State of Mediterranean Forests* will be produced at five-yearly intervals, providing further opportunities to unify and mobilize partners in the management of Mediterranean forests and other wooded lands. We hope and expect that *State of Mediterranean Forests* will become a major tool for communicating with the general public. It will also serve as a vital reference document for the Collaborative Partnership on Mediterranean Forests and all those with a stake in the future of Mediterranean forests and other wooded lands.

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Assistant Director-General
FAO Forestry Department

Hugues Ravenel

Director of Plan Bleu
MAP/UNEP

Table of contents

List of acronyms

..	not available
€	euro
$	United States dollar, unless otherwise specified
AGM	General Directorate of Afforestation and Erosion Control
APCOR	Portuguese Cork Association
CBD	Convention on Biological Diversity
CDM	Clean Development Mechanism
CEC	Commission of the European Communities
Cemagref	Centre National du Machinisme Agricole, du Génie Rural, des Eaux et des Forets
CO_2	carbon dioxide
EF	ecological footprint
EFFIS	European Forest Fire Information System
EFIMED	Mediterranean Regional Office of the European Forest Institute
EUFORGEN	European Forest Genetic Resources Programme
EU	European Union
EU ETS	European Union Emissions Trading Scheme
FAO	Food and Agriculture Organization of United Nations
FAOSTAT	Statistic Division of the FAO
FGR	forest genetic resource
FRA	Forest Resources Assessment
FRM	forest reproductive material
FSC	Forest Stewardship Council
FYROM	The former Yougoslav Republic of Macedonia
FWI	Fire Weather Index
GDP	gross domestic product
gha	global hectares
ha	hectare
HDI	human development index
IFN	national forest inventory
IPCC	Intergovernmental Panel on Climate Change
IPF/IFF	Intergovernmental Panel on Forests/Intergovernmental Forum on Forests
IUCN	International Union for Conservation of Nature
IUFRO	Union of Forest Research Organizations
JI	joint implementation
JRC	Joint Research Centre
m^2	square metre
m^3	cubic metre
MCSD	Mediterranean Commission on Sustainable Development
MODIS	Moderate Resolution Imaging Spectroradiometer
MSSD	Mediterranean Strategy for Sustainable Development
n.s.	not significant

NFP	national forest programme
NGO	non-governmental organization
NGS	next-generation sequencing
NMC	northern Mediterranean country
NWFP	non-wood forest product
OECD	Organization for Economic Co-operation and Development
OWL	other wooded land
SEMC	south-eastern Mediterranean country
SFM	sustainable forest management
SNP	single nucleotide polymorphism
SoMF	State of Mediterranean Forests
TWh	terawatt
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNFF	United Nations Forum on Forests
UNECE	United Nations Economic Commission for Europe
UN-HABITAT	United Nations Human Settlements Programme
UNEP/MAP	United Nations Environment Programme/Mediterranean Action Plan
UN-REDD	United Nations collaborative initiative on Reducing Emissions from Deforestation and forest Degradation
UPF	urban and peri-urban forestry
WHO/Europe	World Health Organization Regional Office for Europe
WMO	World Meteorological Organization

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The State of Mediterranean Forests 2013 (SoMF 2013) represents a major effort of the FAO Committee on Mediterranean Forestry Questions-*Silva mediterranea* and Plan Bleu, FAO's Forestry Department, *Silva Mediterranea* member countries, partners and individual experts many of which gave freely their time and expertise.

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The main Authors:
Gillian Allard (FAO), Nora Berrahmouni (FAO), Christophe Besacier (FAO), Denis Boglio (CTFC), Marion Briens (Plan Bleu), Arnaud Brizay (UNECE/FAO), Andrea Camia (JRC), Lorenza Colletti (Italian State Forest Service), Michela Conigliaro (FAO), Remi D'Annunzio (FAO), Fulvio Ducci (CRA- Arezzo), Marion Duclercq (Plan Bleu), Jean-Luc Dupuy (INRA), Bruno Fady (INRA), Bertille Fages (FAO), Valentina Garavaglia (FAO), Michelle Gauthier (FAO), Jean-Pierre Giraud (Plan Bleu), Roland Huc (INRA), Santiago C. González-Martínez (INIA), Fabrice Gouriveau (CTFC), Carles Gracia (CREAF), François Lefèvre (INRA Avignon), Robert Mavsar (EFIMED), Edouard Michel (Plan Bleu), Marianne Milano (Plan Bleu), Beverly Moore (FAO), Sven Mutke (CIFOR-INIA), Bart Muys (EFIMED), Catherine Numa (IUCN-Med), Marc Palahi (EFI), Renaud Piazzetta (IML), Miriam Piqué (CTFC), Eduard Plana (CTFC), Francisco Rego (ISA), Eric Rigolot (INRA), Fabio Salbitano (University of Florence), Giovanni Sanesi (University of Bari), Jesús San-Migule-Ayanz (JRC), Maria Teresa Sebastià (CTFC), David Solano (CTFC), Marcos Valdebarrano (IUCN-Med), Remi Vayrand (AIFM), Giovanni Giuseppe Vendramin (IGV-CNR).

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1

Towards sustainable development in the Mediterranean: challenges to face

There is a close relationship between development and environmental issues in the Mediterranean region (Figure 1.1). With a population (in 2010) of 507 million people on three continents and an extremely rich natural and cultural heritage, the Mediterranean is an "ecoregion", in which human and economic development is largely dependent on sometimes-scarce natural resources and a vulnerable environment. After thousands of years of co-evolution between ecosystems and societies, human activities are creating substantial environmental pressure, with significant disparities between the northern, southern and eastern rims. This chapter gives a regional overview of the challenges facing forest management in the Mediterranean region.

The Mediterranean region in numbers, 2010

6.5% of land mass

7.7% of the global population

13.5% of global GDP (16.2% in 1990)

32% of international tourism

60% of people living in water-poor countries globally

7.7% of CO_2 emissions

Figure 1.1. Countries of the Mediterranean region, Mediterranean bioclimatic and watershed limits. The watershed limit is defined by topography and the resulting runoff patterns of rainwater; the bioclimatic limit is the limit of the Mediterranean region in term of vegetation and climate.
Source: Plan Bleu from Ewing *et al.*, 2010.

Socio-economic division on each side of the Mediterranean

Human development

The human development index (HDI), calculated according to life expectancy, education and gross domestic product (GDP) per capita, is a measure of social well-being. It shows significant disparities between countries in the Mediterranean region, particularly with respect to poverty (Figure 1.2).

Figure 1.2. Human development index, Mediterranean region, 2011
Source: Based on UNDP, 2011.

In 2011, the average HDI in the Mediterranean was 0.76, which was higher than the global HDI (0.68). HDI has increased steadily in all countries in the Mediterranean region since 1990, but major disparities remain. In 2011, HDI was above 0.80 for 10 of the 27 Mediterranean countries and below 0.70 in 8. Israel had the highest HDI in the Mediterranean region (0.89) and ranked 17th among 187 countries globally, while Morocco had the lowest HDI (0.58) and ranked 130th globally. HDI data suggest that poverty levels are still high in Egypt, Morocco, Palestine and the Syrian Arab Republic.

Unsustainable development trajectories

The ecological footprint (EF) measures the biologically productive surface area required to produce the resources consumed by a person or population and to absorb the waste[1] generated (through eating, housing and travel, etc.), taking into account the resource

[1] The EF does not take into account certain environmental impacts, such as the pollution of soil and water resources caused by agricultural practices, or toxic waste production.

management processes in effect. EF is expressed in global hectares (gha) per capita, where 1 gha measures the average productivity of all biologically productive areas, measured in ha, on earth in a given year. Biocapacity, which is also expressed in gha, is the available biologically productive surface area and reflects the availability of natural resources. It represents the EF threshold, beyond which the use of resources is unsustainable.

Comparing the EF ("demand") and biocapacity ("supply") provides an indication of the pressure exerted by a population on natural resources and, in turn, of the environmental sustainability of that population's lifestyle.

Biocapacity in the Mediterranean region was estimated at 1.3 gha per capita in 2007, which was 16 percent lower than in 1961 (1.5 gha per capita). It was also lower than the (2007) global value of 1.8 gha per capita. The average EF in the Mediterranean region in 2007 was 3.1 gha per capita, which was higher than the global EF of 2.7 gha per capita and much higher than the estimated biocapacity of the region. The EF in the Mediterranean region increased by 52 percent between 1961 (2.1 gha per capita) and 2007, due mainly to an increase of 185 percent in the carbon component of the EF. Components of the EF related to other natural resources did not increase to the same extent: by +29 percent for agricultural land; +23 percent for forests; +20 percent for developed land; -6 percent for pastureland; and -54 percent for fishing (Figure 1.3).

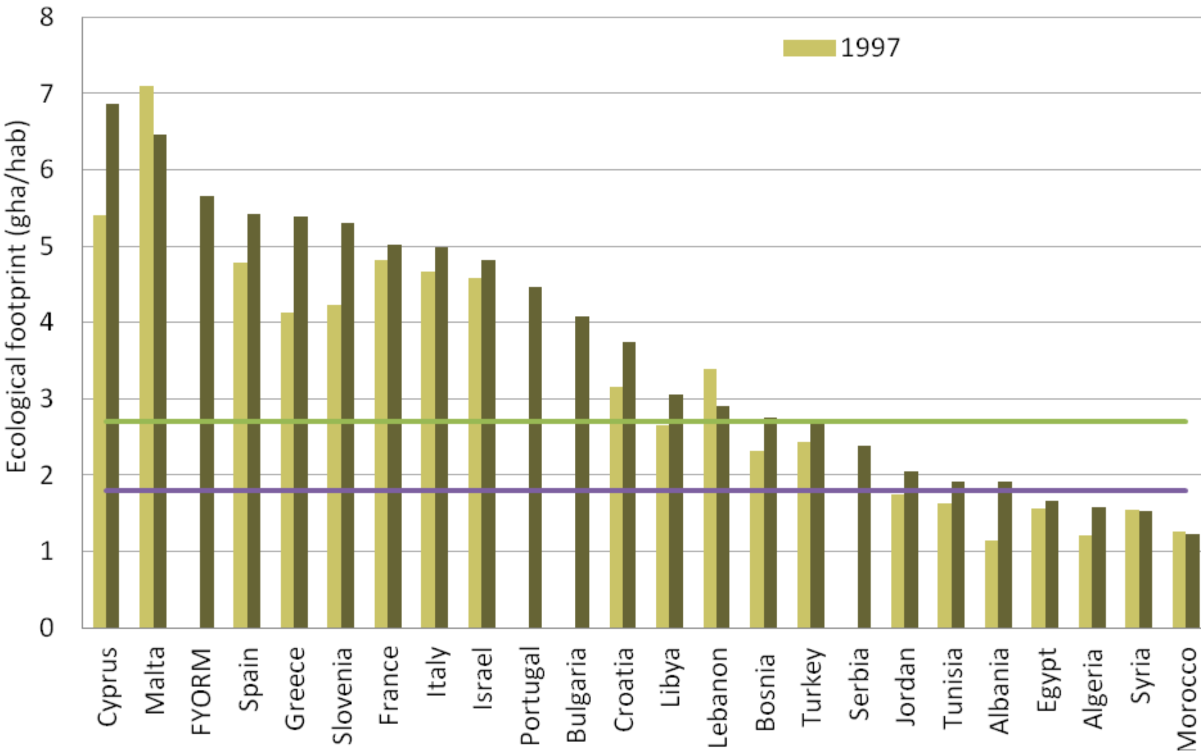


Figure 1.3. Ecological footprint, Mediterranean countries, 1997 and 2007 Note: World average ecological footprint and world-average biocapacity are represented respectively in green and violet. FYROM = The former Yugoslav Republic of Macedonia; Syria = Syrian Arab Republic.
Source: Plan Bleu from Ewing *et al.*, 2010.

In only four countries (Algeria, Egypt, Morocco and the Syrian Arab Republic) was the EF below the biocapacity threshold in 2007 (compared with seven countries in 1997). In only four countries (Lebanon, Malta, Morocco and the Syrian Arab Republic) did the EF decrease between 1997 and 2007 (although note that numbers can fluctuate significantly from year to year).

There were significant disparities in EFs between northern Mediterranean countries (NMCs) and southern and eastern Mediterranean countries (SEMCs) (Figure 1.4).[2] The NMCs accounted for the top 12 EFs in the Mediterranean region, while the SEMCs accounted for the lowest four. In 2007, the average EF was 4.69 gha per capita for the NMCs and 2.02 for the SEMCs.

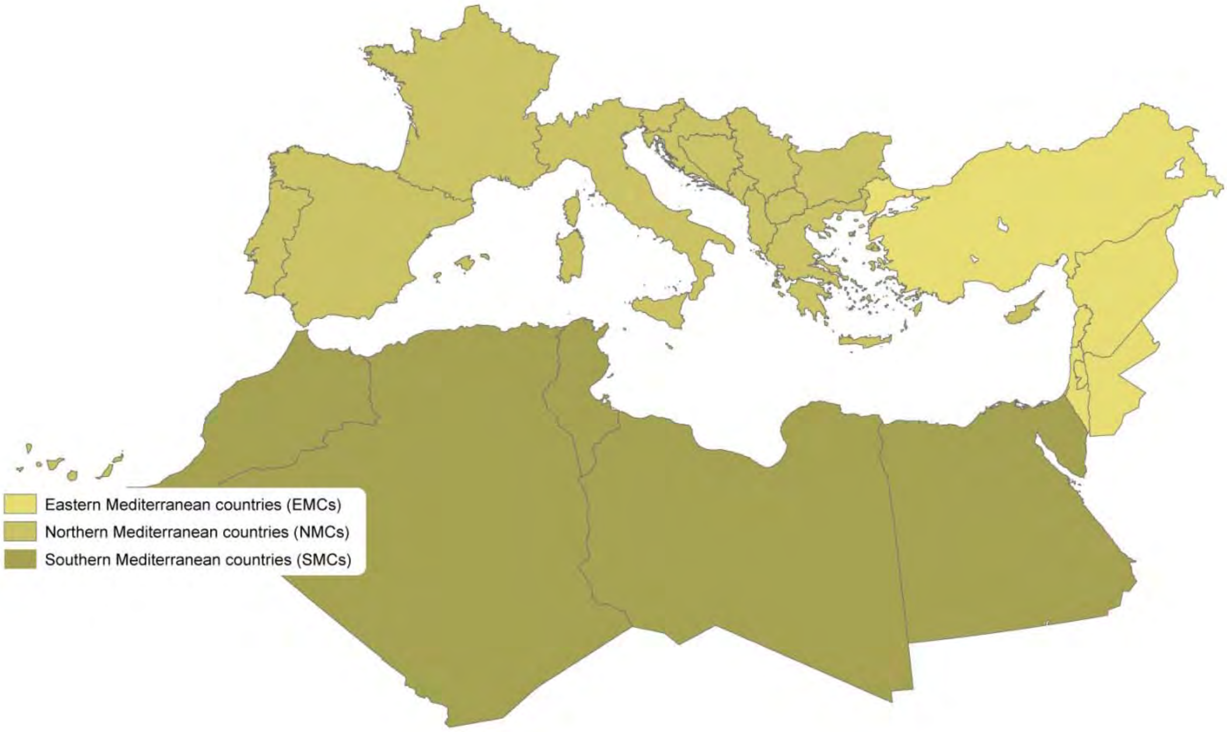


Figure 1.4. The eastern, northern and southern Mediterranean subregions.
Source: FAO.

The increase in EF in most countries in the Mediterranean region indicates growing pressure on resources as a result of unsustainable methods and levels of consumption. It also highlights the difficulty of implementing sustainable development policies.

[2] Figure 1.4 shows these as three subregions, but mostly the eastern and southern subregions are dealt with collectively in the term SEMCs.

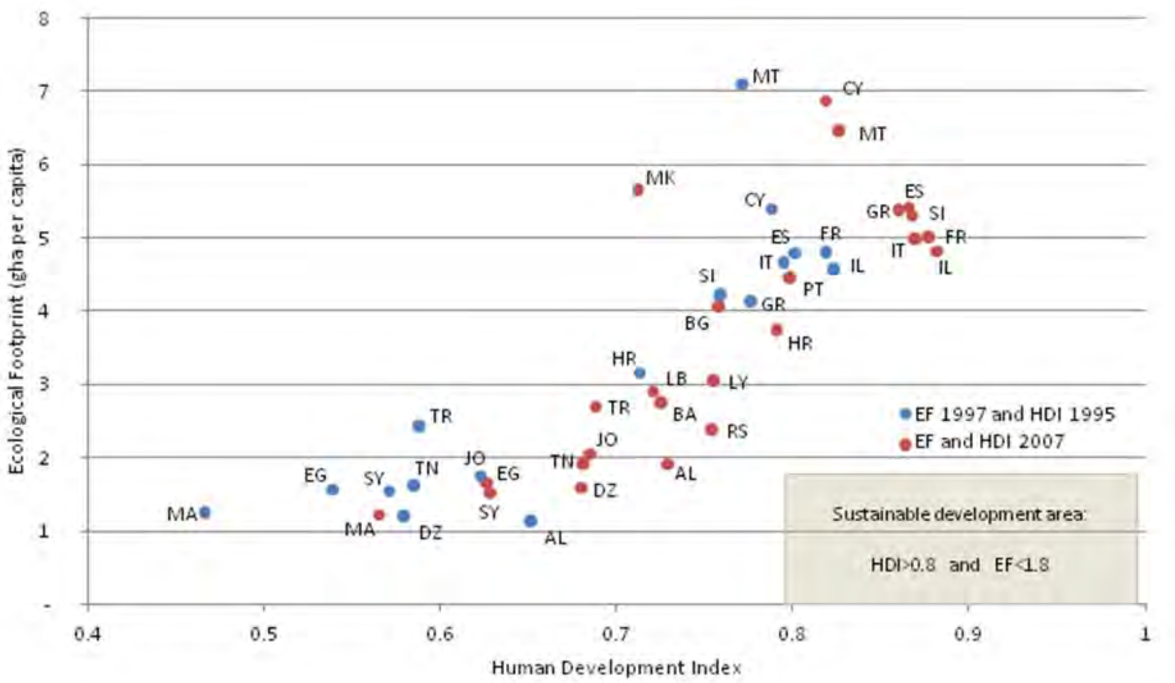


Figure 1.5. Ecological footprint (EF) and human development index (HDI), Mediterranean countries, 2007.
Source: Plan Bleu from World Bank, 2011.

A country's situation is considered to be compatible with sustainable development if its HDI is above 0.8 and its EF is less than 1.8 global hectares per capita (Figure 1.5). In 2007, no Mediterranean countries (and none globally) were in this "sustainable development" zone. HDI increased in all countries in the Mediterranean region between 1997 and 2007, but only two (Lebanon and Malta) significantly reduced their EFs per capita. The relatively low EFs (*i.e.* lower than the global average of 1.8 gha per capita) in Algeria, Egypt, Morocco and the Syrian Arab Republic are due mainly to constraints related to the arid climate in those countries. Their low HDIs reflect a high dependency on natural resources and significant levels of poverty.

The challenge for countries with a median or high HDI, such as the Balkan states and the southern Mediterranean countries, is to continue their human development while implementing measures to control or decrease their EFs. The challenge for countries with very high HDIs – the European Union (EU) member states and Israel – is to maintain this level while reducing their EFs.

Demographics: stabilization in the north, transition in the south and east

The population of the Mediterranean region doubled between 1955 and 2010 (Figure 1.6), due mainly to the SEMCs, where the population increased by 238 percent in the period. In 1955, the SEMCs accounted for just over one-third of the region's population and in 2010 they accounted for more than half. Figure 1.6 shows changes in population in the countries of the Mediterranean region between 2000 and 2010.

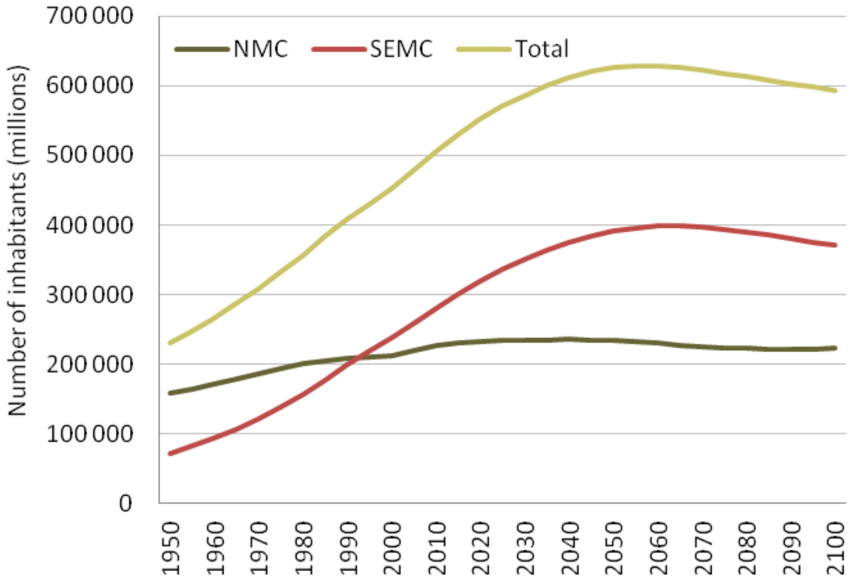


Figure 1.6. Population growth in Mediterranean countries, 1950–2010.
Source: United Nations, Department of Economic and Social Affairs, Population Division, 2011.

The population in the region is projected to increase for some years (driven mainly by the SEMCs), before stabilizing and beginning to decrease by 2050 (Figure 1.7). The population is projected to start declining by 2030 in the NMCs and by 2060 in the SEMCs.

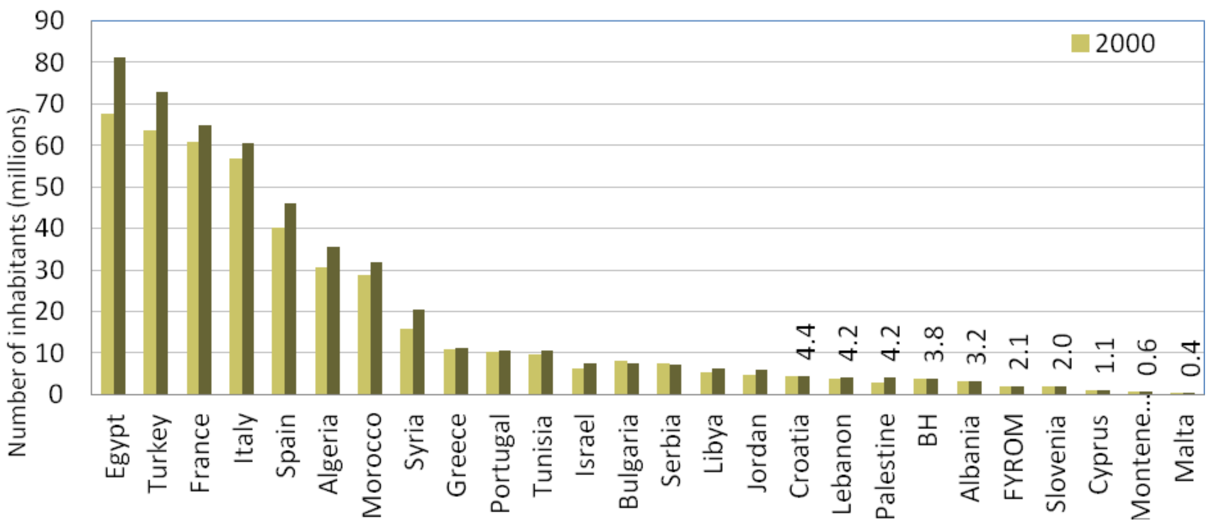


Figure 1.7. Population in Mediterranean countries, 2000 and 2010.
Note: BH = Bosnia and Herzegovina; FYROM = The former Yugoslav Republic of Macedonia; Syria = Syrian Arab Republic.
Source: United Nations, Department of Economic and Social Affairs, Population Division, 2011.

The seven most populated countries (in Egypt, Turkey, France, Italy, Spain, Algeria and Morocco, in descending order by population) account for three-quarters of the Mediterranean population but have differing growth rates (Figure 1.7). Between 2000 and

2010, the population increased by 20 percent or more in the majority of SEMCs (Egypt, Israel, Jordan, Libya and Syrian Arab Republic) and by 11–20 percent in the other SEMCs.

Up to 1990, the population increased in all the NMCs and continued in most countries to 2010 with the exceptions of Albania, Bulgaria, Bosnia and Herzegovina, Croatia, Montenegro and Serbia, due mainly to significant emigration with the fall of the "Iron Curtain".

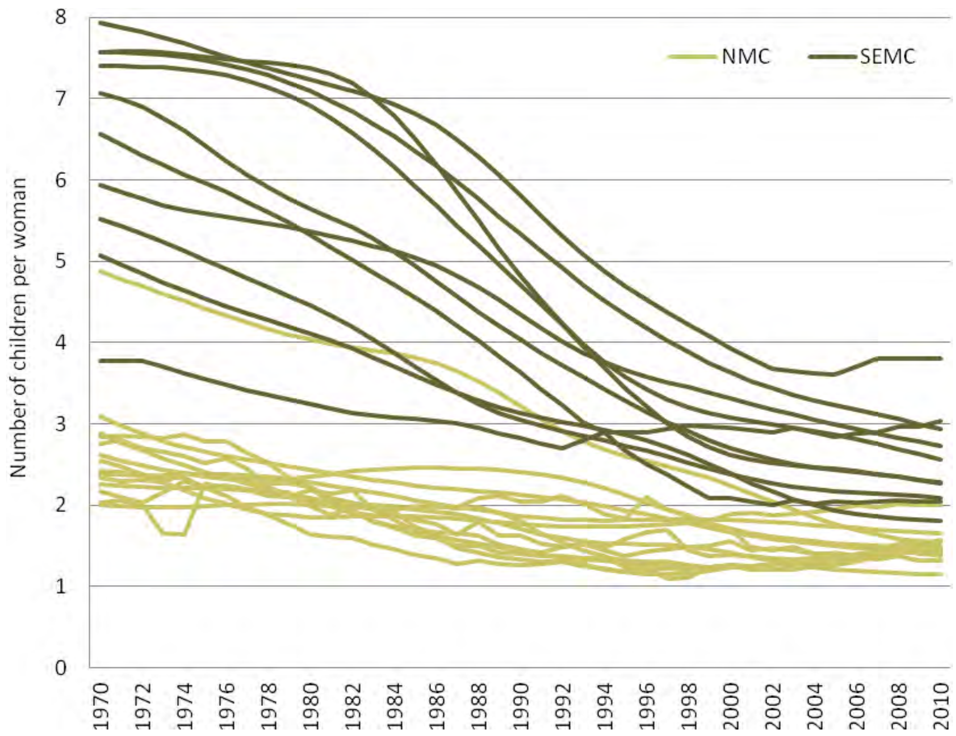


Figure 1.8. Number of children per woman of child-bearing age, NMCs and SEMCs
Source: United Nations, Department of Economic and Social Affairs, Population Division, 2011.

Fertility rate (the number of children per woman of child-bearing age) is a measure of demographic dynamics. Figure 1.8 shows that the decline in fertility rate in the Mediterranean has been particularly rapid in the SEMCs. Overall, the fertility rate was above the replacement fertility rate (2.05) in all NMCs except Croatia and Malta in 1970 but in only 8 in 2010.

Population growth rates vary greatly between NMCs and SEMCs but seem to be converging. Considerable structural differences remain, however: the population of the SEMCs is much younger than that of the NMCs. In the NMCs, the proportion of people aged under 15 decreased from 22.7 percent of the total population in 1990 to 16.2 percent in 2010, while the proportion of people in the over-65 age bracket increased from 10.8 percent to 15.3 percent. In the SEMCs, the proportion of people aged under 15 decreased from 40.9 percent to 30.5 percent over the period and the proportion of people aged over 65 increased from 4.1 percent to 5.5 percent. While the population in the SEMCs is projected to stabilize eventually, the current growth is accompanied by a lack of employment opportunities and is contributing to considerable social pressure.

Continuous, poorly managed and mainly coastal urban sprawl

In general, population growth in the region is concentrated in urban and coastal areas. The urban population is increasing in both the NMCs and the SEMCs (Figure 1.9); in the SEMCs, the urban population doubled between 1950 and 2010. The rural population declined in the NMCs over the period but increased in the SEMCs, where it is projected to stabilize and start declining between 2020 and 2050.

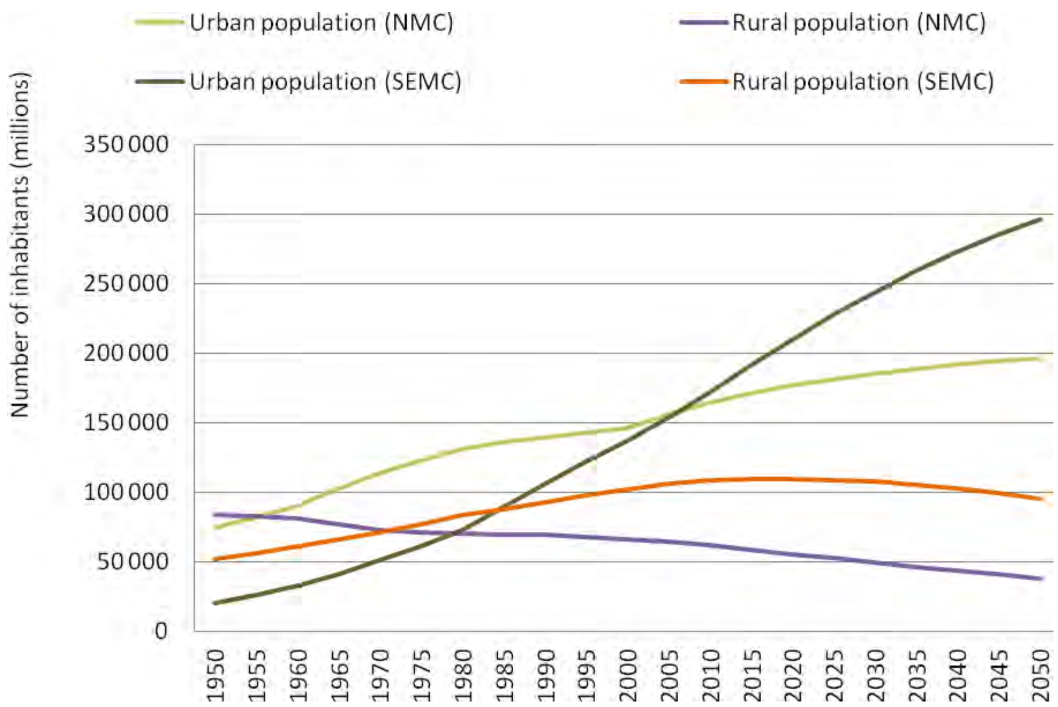


Figure 1.9. Population trends in Mediterranean countries, 1950–2050
Source: United Nations, Department of Economic and Social Affairs, Population Division, 2011.

In the SEMCs, the extent and pace of urbanization is rarely planned, and urban growth is exceeding the capacity of many countries to meet infrastructural and employment needs. Depending on the country and urban area, 30–70 percent of city-dwellers in the SEMCs are able to construct their housing only by resorting (legally or illegally) to the informal sector. As a result, urban areas develop in an uncontrolled way and often lack adequate access to water, sanitation and other basic urban services.

High population density in cities generates considerable problems. For example, youth unemployment is above 30 percent in several SEMCs and there is a lack of access to facilities and essential services. This urbanization is occurring mainly in coastal areas and as sprawls on the outskirts of urban centres, which intensifies pressure on resources and aggravates the fragmentation and even destruction of already vulnerable coastal and peri-urban ecosystems. Figure 1.10 shows the growth of population centres in the Mediterranean region, especially in some SEMCs and in coastal areas.

A worrisome demographic situation, a source of environmental pressure

On the whole, the demographics of the Mediterranean region can be characterized by an increase in total population, and by significant disparities which nevertheless seem to be waning. The general trend, which is more distinct in the NMCs, is a decreasing birth rate and an aging population that should lead to a decline in the region's population from 2050. By then, the population could exceed 626 million, a 20 percent increase over 2010. While, overall, the population of rural areas could be in decline by 2015, increasing demographic pressure in urban, peri-urban and coastal regions remains a crucial challenge. The development trajectories of Mediterranean countries appear to be unsustainable.

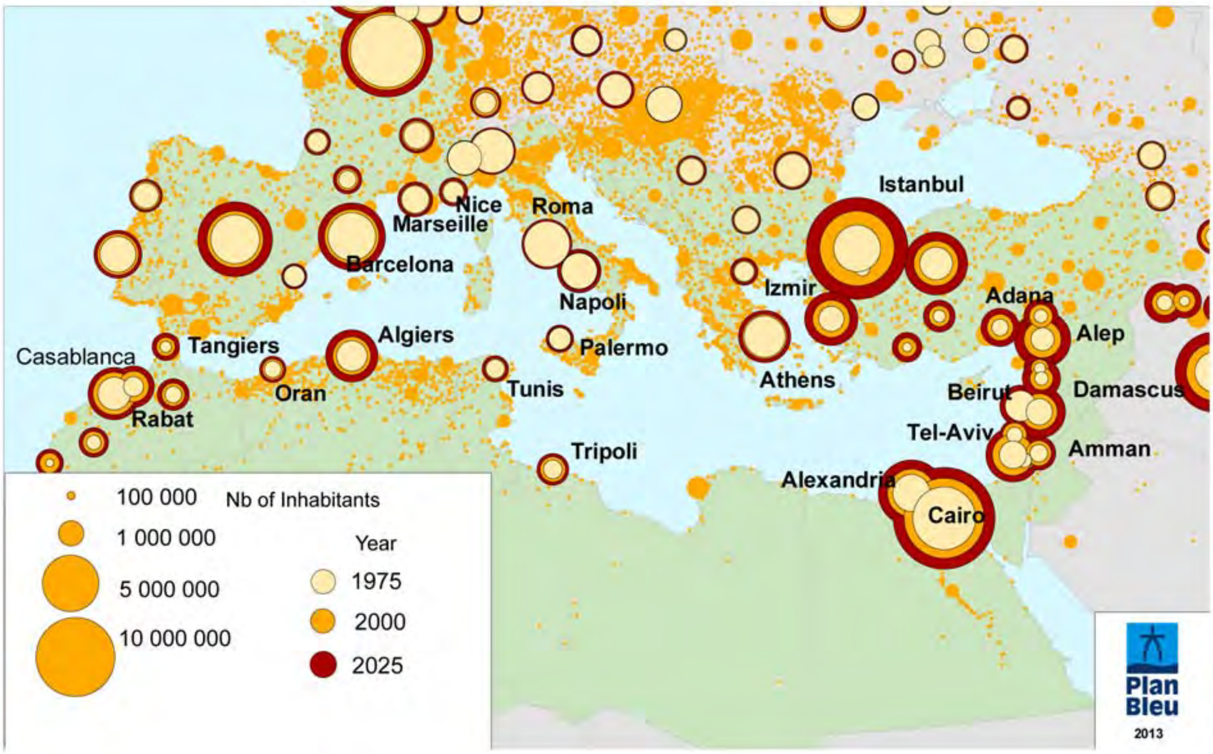


Figure 1.10. Urban population distribution and increase in Mediterranean countries, 2011
Source: United Nations, Department of Economic and Social Affairs, Population Division, 2011.

Growing yet unevenly distributed economic wealth

The GDP of the Mediterranean region constituted 13.5 percent of world GDP in 2010, down from 16.2 percent in 1990. GDP per capita in the region was 76 percent higher than the global average.

There are major subregional disparities, with the NMCs accounting for 80 percent of total GDP in the region in 2010. This was a slight decrease from 2000 (Figure 1.11) due to a comparatively higher GDP growth rate in the SEMCs, where GDP increased by 48 percent in the decade compared with 12 percent in the NMCs.

Figure 1.12 confirms the disparity between NMCs and SEMCs. For example, nine of the ten countries with the highest GDP per capita in the region are NMCs, and five of the ten countries with the lowest GDP per capita are SEMCs. These differences are considerable: the GDPs per capita in Cyprus and France are ten times higher than those in the Syrian Arab Republic and Algeria, respectively. The Balkan states are an intermediate group. GDP per capita is above US$10 000 in Greece and Slovenia and about US$6 000 in Croatia, but it is similar to the southern Mediterranean countries in the other Balkan states.

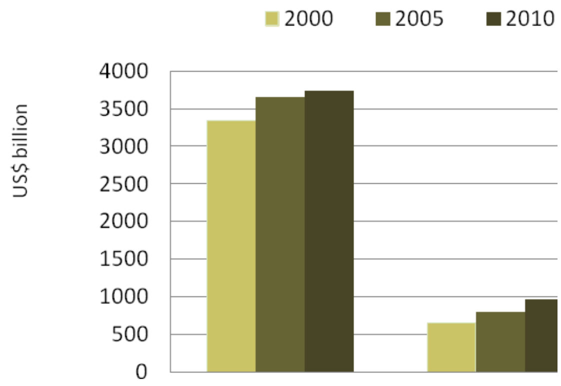


Figure 1.11. GDP, Mediterranean countries, 2000, 2005 and 2010
Source: Plan Bleu from World Bank, 2011.

Unemployment, especially among the young

Figure 1.13 shows that, in 2010, unemployment exceeded 20 percent of the working population in The former Yugoslav Republic of Macedonia, Palestine and Spain. In most other countries in the Mediterranean region, unemployment was roughly 10 percent, which was well above the world average of 6–7 percent. Unemployment among people aged under 25 remains worryingly high in most countries in the region; rates below 20 percent are exceptions.

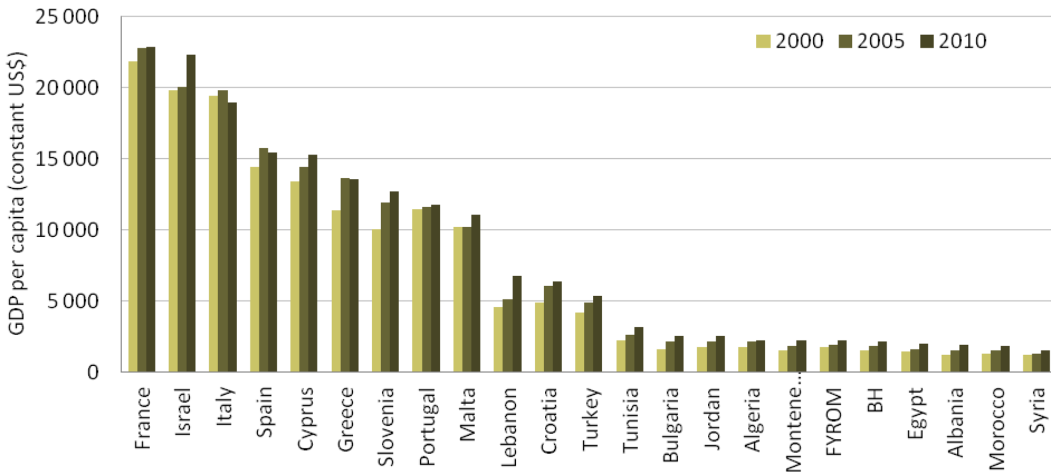


Figure 1.12. GDP per capita, Mediterranean countries, 2000, 2005 and 2010
Note: BH = Bosnia and Herzegovina; FYROM = The former Yugoslav Republic of Macedonia; Syria = Syrian Arab Republic.
Source: Plan Bleu from World Bank, 2011.

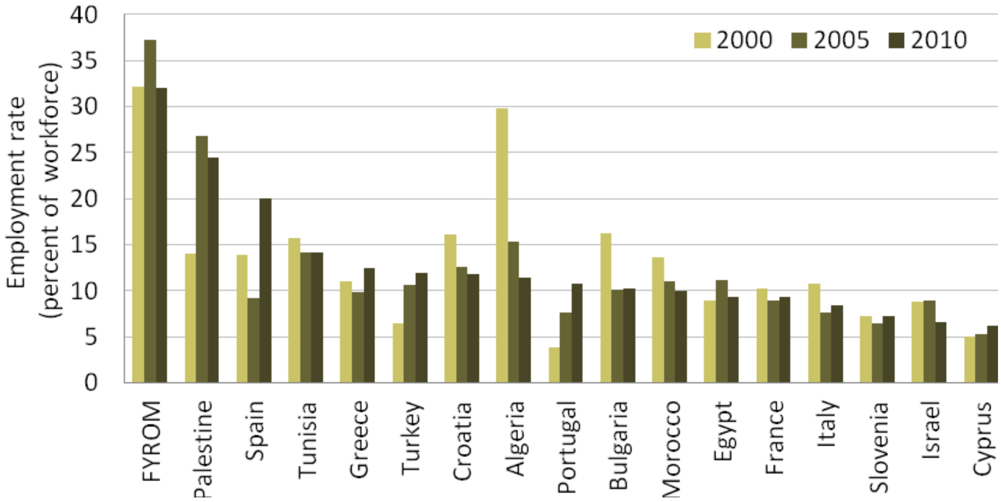


Figure 1.13. Unemployment in Mediterranean countries, 2000, 2005 and 2010
Note: FYROM = The former Yugoslav Republic of Macedonia.
Source: Plan Bleu, 2012.

Towards economies based on an expanded service sector

In the Mediterranean region and especially in the NMCs, the economy is increasingly dominated by services. In the NMCs an increase in services has corresponded with a decline in the contribution of the agricultural and industrial sectors: services generated 60 percent of GDP in 1998 and 67 percent in 2008, while the contribution of agriculture decreased from 10 percent to 6 percent over the period and industry's contribution decreased from 30 percent to 27 percent.

In the SEMCs, the contribution to GDP is growing for the industry (from 32 percent in 1998 to 35 percent in 2008) and services (from 54 percent to 55 percent) sectors, and declining for agriculture (from 14 percent to 10 percent).

In both the NMCs and the SEMCs, agriculture is therefore less dynamic than other sectors of the economy, despite an increase in the added value it generates. The rural exodus to cities is clear in the demographic data. The rural population has been in decline since the 1960s in the NMCs and since the mid 1980s in the SEMCs (Figure 1.14). In the NMCs, the rural population decreased by half between 1995 and 2010 (to 11 million people). In the SEMCs, the rural population declined from 69 million people in 1985 to 60 million in 2010. This decline is projected to continue to at least 2020 in both subregions.

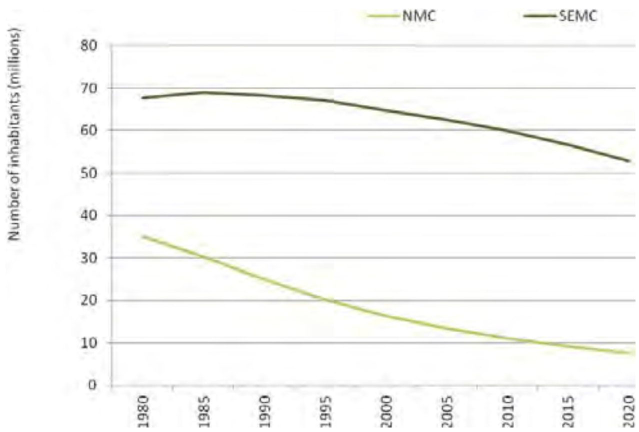


Figure 1.14. Rural population, Mediterranean countries, 1980–2020
Source: FAOSTAT, 2012.

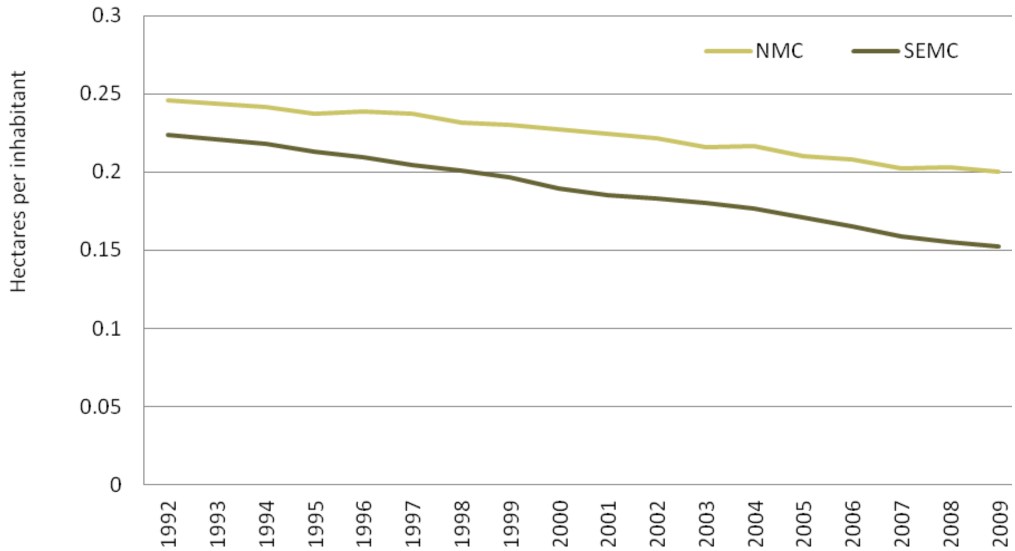


Figure 1.15. Area of arable lands, NMCs and SEMCs
Source: FAOSTAT, 2012.

The rapidly growing total population, and its urbanization, is having an effect on the availability of arable land (Figure 1.15). In 2009, arable land comprised 2.5 percent of the total land area in the NMCs and only 0.6 percent in the (often more arid) SEMCs. The area of arable land per capita continues to decrease, diminishing by half in 40 years.

Tourism is an emblematic economic sector in the Mediterranean region. Tourist arrivals in the region increased by 100 million between 1997 and 2008; in 2010, tourist arrivals in the region represented 32 percent of global tourism. Tourism spending comprises 1.5–2 percent of GDP in the Mediterranean region, although there are major national and local disparities. In 2010, for example, foreign tourist spending accounted for 13 percent of GDP in Lebanon and 0.7 percent in Turkey. There are significant local differences in Turkey; for example, tourism accounted for more than 60 percent of the GDP of Alanya Province in 2011.

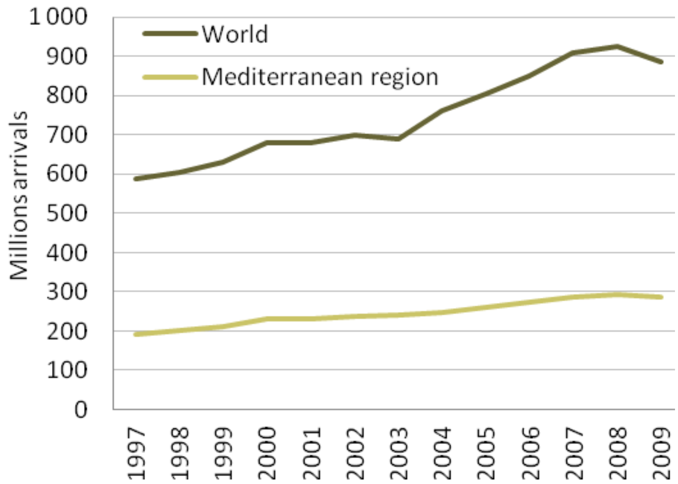


Figure 1.16. Tourism arrivals, Mediterranean countries, 1997–2010

Mediterranean tourism is dominated by three countries: France, Spain and Italy. In 2010, these countries received approximately 60 percent of all inbound tourists in the Mediterranean (26 percent, 18 percent and 15 percent, respectively) and 70 percent of their spending (Figure 1.16).

Although the tourism sector is responsible for the direct redistribution of wealth through the jobs that it generates, it is sensitive to economic downturns and, in at least some SEMCs, to political disturbances. The wealth and jobs generated by tourism benefit local people to only a moderate degree as the use of foreign seasonal workers is widespread.

Interdependent economies

The NMCs have traditionally been somewhat dependent on the SEMCs for their energy needs, and the SEMCs have typically had a level of dependence on the NMCs for financial flows (aside from direct investments). In addition to investments, the southern Mediterranean countries and eastern European Mediterranean countries (*i.e.* the Balkans, excluding Greece) receive foreign capital through public aid mechanisms and the transfer of funds from workers living abroad. These financial flows are significant economic levers and demonstrate varying degrees of dynamism and economic dependence (Figure 1.17). Foreign direct investment is the main financial flow to eastern Mediterranean countries. Funds transferred from people living abroad were the main financial flow to southern Mediterranean countries in 2007–2010, although foreign direct investment is also increasing. Inflows from people living abroad are particularly high in the Maghreb and contribute to the balance of external accounts. However, they are mainly used to purchase consumer goods and real estate.

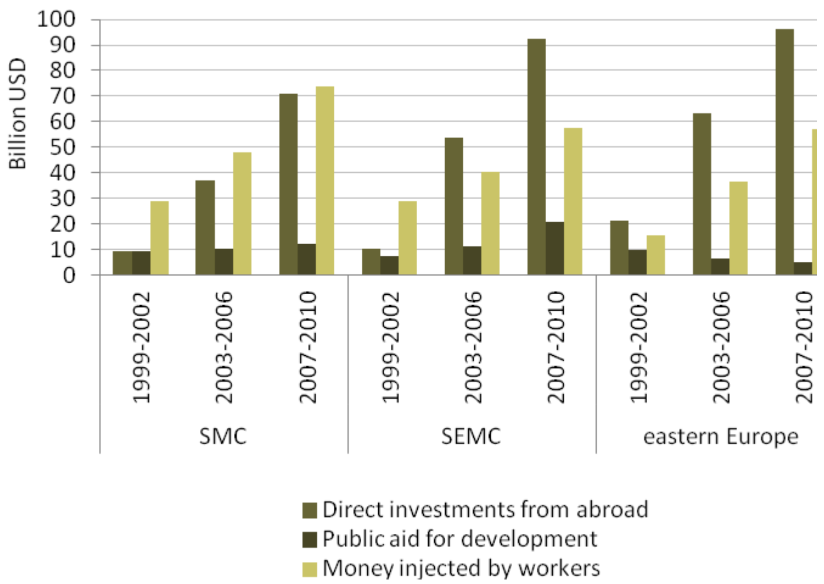


Figure 1.17. Sources of financial flows to Mediterranean countries, 1999–2002, 2003–2006 and 2007–2010
Source: Plan Bleu from World Bank, 2011.

The relative share of public aid is decreasing: it accounted for 18 percent of incoming funds in the SEMCs in 1999–2002 and 10 percent in 2007–2010. The relative increase in foreign direct investment in SEMCs suggests that their economies are becoming increasingly dynamic and capable of generating their own income.

The EU is the main economic partner of the SEMCs, particularly in the Maghreb. These strong interdependencies should continue to grow, especially in gas and electricity, further strengthening economic ties between the subregions.

North–south integration: between free trade priorities and sustainable development objectives

In the Mediterranean, conflicts and other instability have affected several Middle Eastern and Balkan countries and subregions in the last 30 years. In the northern Mediterranean, the inclusion of several Mediterranean countries in the EU contributed to significant progress in terms of peace, democracy and economic and political integration. In the south and east, however, there is no equivalent integration process. Despite several initiatives, the region remains subject to persistent conflicts and a lack of structured cooperation.

The Euro-Mediterranean Partnership, or "Barcelona Process", was initiated in 1995 with the ambitious goal of creating an "area of stability and shared prosperity". However, this Euro-Mediterranean cooperation, integrated into the European Neighbourhood Policy since 2003, still needs to be improved in terms of resources, reciprocal commitments and spill-over effects. Up to 2008, the Euro-Mediterranean Partnership focused mainly on security and trade liberalization, with the aim of creating a free-trade zone and bilateral approaches. It did little to include environmental and sustainable development issues in its priorities and funding.

The Action Plan for the Mediterranean (1975) and the Convention for Protection against Pollution in the Mediterranean (1976, known as the Barcelona Convention) were established under the aegis of the United Nations Environment Programme and provide the institutional framework for regional cooperation is centred specifically on environmental protection and sustainable development. These regional plans originally targeted marine pollution and were broadened in 1995 to include other sustainable development issues (*e.g.* energy, transport, tourism and rural development).

This dynamic was reinforced in 1996 with the creation of the Mediterranean Commission on Sustainable Development (MCSD). The MCSD acts as a consultative body and is designed as a forum for dialogue, exchange and proposals for its Parties and their partners. It has 36 members, with representatives from networks of local authorities, socio-economic players and NGOs specialized in the environment and sustainable development. In 2001, the Parties of the Barcelona Convention asked the MCSD to develop the Mediterranean Strategy for Sustainable Development (MSSD), which was adopted in 2005.

The MSSD promotes the gradual integration of environmental concerns into economic development through the following objectives:

- contribute to economic development by enhancing Mediterranean assets;
- reduce social disparities by implementing the Millennium Development Goals and strengthen cultural identities;
- change unsustainable production and consumption patterns and ensure the sustainable management of natural resources;
- improve governance at the local, national and regional levels.

The MSSD identifies seven priority areas of action: integrated management of water resources and demand; improved rational use of energy with increased renewable energy use and mitigation of, and adaptation to, climate change; sustainable mobility through appropriate transport management; sustainable tourism as a leading economic sector; sustainable agriculture and rural development, including the sustainable management of forests; sustainable urban development; and sustainable management of the sea, coastal areas and marine resources.

By reinforcing these initiatives launched within the framework of the Barcelona Process, the Union for the Mediterranean was created in 2008 with the goal of improving the political visibility of regional integration and to facilitate this in the areas of water, the environment, transport, energy, education and research, and support for small and medium-sized enterprises. The Union for the Mediterranean has 44 members – the countries of the EU and the Mediterranean region as well as Jordan, Mauritius and the Arab League. Libya is an observer nation.

This 20-year regional process has been critical in achieving more structured governance in the Mediterranean, which has nevertheless been affected by the fragmentation process that has also been seen at the global scale. The MCSD was innovative in its integration of civil society from inception, but its operation and relationships with governments and international players have revealed weaknesses. The MCSD could benefit from closer collaboration in the social and economic areas of sustainable development in order to achieve greater regional cooperation.

Increasing pressures on the environment

At the heart of development in the Mediterranean region are environmental pressures arising from its growing population, especially in the south and east, the increasing exploitation of natural resources, particularly water, and intensified natural risks associated with climate change. Natural land ecosystems in the Mediterranean are rich in biodiversity, with a high level of endemism, and there has been a significant increase in forests in the north due to the abandonment of marginal agricultural lands and tree-planting campaigns. In the south, forest ecosystems are still threatened, particularly in the Maghreb, due to clearing and farming on marginal lands, the overuse of fuelwood, and overgrazing. Closely integrated into local and regional economies since Antiquity, traditional uses of wooded lands and pastoral areas are being increasingly abandoned in the north but are still essential in the south. The ecosystem services provided by these areas – such as the protection of soil and water, protection against erosion and desertification, carbon sequestration and biodiversity conservation – are increasingly recognized. However, these services are threatened by degradation. Pressures include overuse in the south and, in the north, an increasing risk of forest fire as forest fuel loads increase and the climate becomes drier.

The ecological footprints and more generally the development trajectories of Mediterranean countries show alarming signs of unsustainability. Key points concerning pressures on resources and the main risk factors are described below.

Threatened biodiversity

> About 18 percent of Mediterranean species are threatened with extinction.
>
> Five oak species endemic to the Mediterranean are threatened with extinction.
>
> Protected areas are unequally distributed in the region, more than 90 percent being in the northern part of the region.

The Mediterranean region is a highly complex environment due to the interactions between multiple factors such as climate, geomorphology, soil, hydrology and land use. It is estimated that around 25 000 plant species inhabit the region (Myers et al., 2000), of which about 60 percent are endemic (Thompson et al., 2005), making it one of the highest concentrations of endemic plants in the world (Myers et al., 2000). The region is regarded as a biodiversity hotspot because of its high endemism and because it is experiencing a widespread loss of habitat, making its conservation a priority. Table 1.1 details this species' diversity and the levels of endemism and threat.

Mediterranean ecosystems have been strongly linked to human activity for millennia, although the impact of such activity differs between the north and south of the region and the current model of development is increasing pressure on the environment. The consequent loss of biodiversity affects economic potential by reducing human welfare (*e.g.* health, food and other ecosystem services) and by limiting options. The priority challenges for biodiversity conservation are therefore linked to economic inequalities.

Environmental pressure is rising, particularly as a result of tourism, urban concentration in coastal areas, the development of intensive agriculture, the overexploitation of natural resources, overgrazing and the abandonment of traditional agricultural practices. Some effects of these pressures, such as changes in vegetation cover and habitat loss, can be estimated, but others are very difficult to quantify.

It is estimated that only 5 percent of the original vegetation remains relatively intact in the region. According to the IUCN Red List, about 124 plant species found in forests in the Mediterranean region are threatened with extinction. For example, two oak species endemic to the Mediterranean (*Quercus pauciradiata* and *Q. orocantabrica*) are classed as critically endangered (Oldfield and Eastwood, 2007). Region-wide recent studies (*e.g.* Cuttelod *et al.*, 2009) suggest that about 18 percent of the species in the various taxonomic groups listed in Table 1.1 are threatened with extinction.

Table 1.1. Biodiversity in the Mediterranean region

	Estimated no. of species	Endemic species	Threatened species	Species classified as data deficient
Plants	25 000	11 700	118*	1
Aquatic plants	469**	150	73	12
Invertebrates				
Dragonflies and damselflies	162	23	31	5
Freshwater crabs	12	5	1	0
Mollusc	155**	82	70	26
Fishes				
Marine fishes	515	75	43	149
Freshwater fishes Endemic	253**	253	142	41
Amphibians	112	76	34	0
Reptiles	351	169	47	19
Birds	601	16	22	0
Terrestrial mammals	296	88	48	37
Marine mammals	9	1	5	4

Note : "Threatened" = the estimated total number of species in the threatened categories of the IUCN Red List (*i.e.* critically endangered, endangered or vulnerable), 2012. * 50 threatened species of plants were assessed on 12 islands of the Mediterranean region, 2012. ** Number of assessed species according to the Mediterranean Red List, 2012.
Source: IUCN Red List and Cuttelod *et al.*, 2009.

The majority of Mediterranean countries have signed the following eight multilateral agreements in the past 40 years, demonstrating their willingness to commit to ecosystem and biodiversity conservation: the Ramsar Convention; the Barcelona Convention; the Convention on International Trade in Endangered Species of Wild Fauna and Flora; the Convention on Biological Diversity; the Bern Convention; the Bonn Convention; the EU Habitats and Birds Directives; and the African Convention on the Conservation of Nature and Natural Resources. The number of protected areas (with varying degrees of protection) has also increased in the Mediterranean region in the last 40 years, to more than 4 200. Ninety-five percent of protected areas in IUCN protected-area categories I–IV are located in the NMCs, but the number of areas with some sort of regulated management scheme has increased in the SEMCs and there are about 200 areas in IUCN protected-area categories I–IV in that subregion (Figure 1.18).

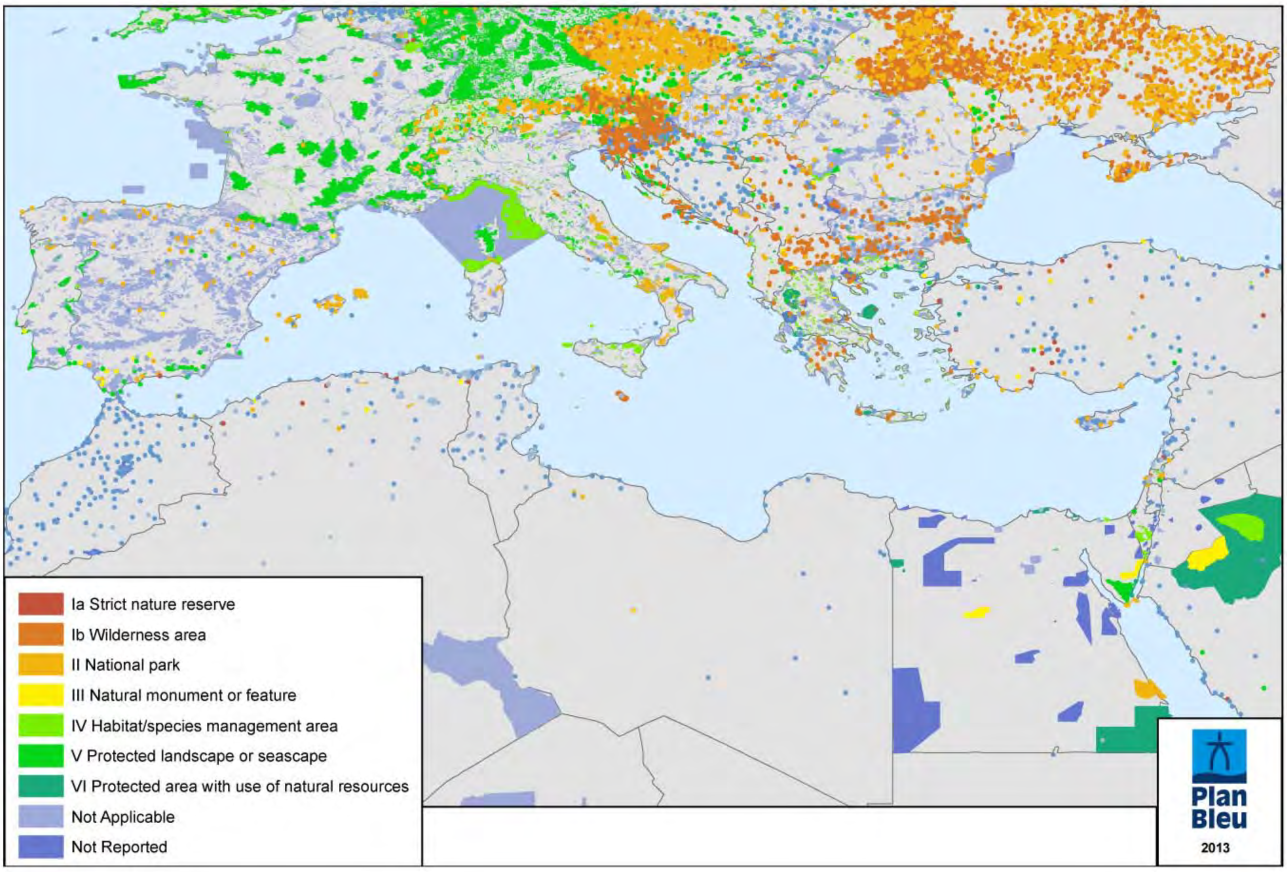


Figure 1.18. Distribution of protected areas, by IUCN category, Mediterranean region, 2010
Source: IUCN and UNEP-WCMC, 2012.

Water: a scarce and unequally distributed resource

A water-poor country is defined as a country with less than 1 000 m^3 of water per person per year. Sixty percent of people living in water-poor countries globally live in the Mediterranean region. There are considerable inequalities within the region in terms of water availability and the extent of renewable resource use. In 2009, France, Italy, Spain and Turkey accounted for 67 percent of renewable fresh water resources (flows available within their own borders on an annual basis) in the region.

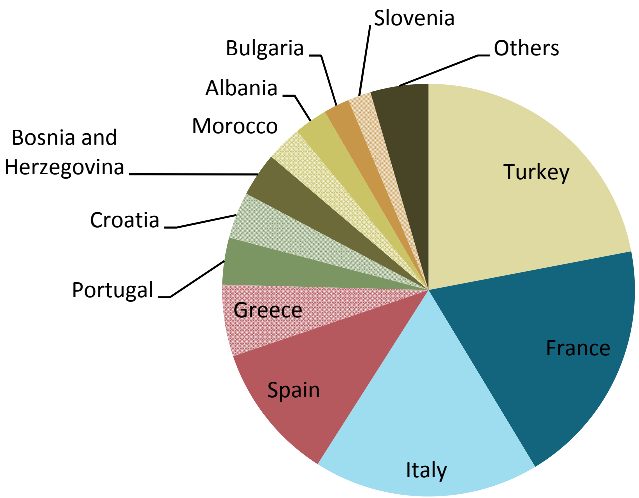


Figure 1.19. Water resources, Mediterranean countries, 2012
Source: FAOSTAT, 2012, AQUASTAT database.

The SEMCs accounted for a little more than one-quarter (27 percent) of the region's water resources in 2009 (Figure 1.19). If Turkey is excluded, they accounted for only 6 percent, yet they are home to 40 percent of the region's population.

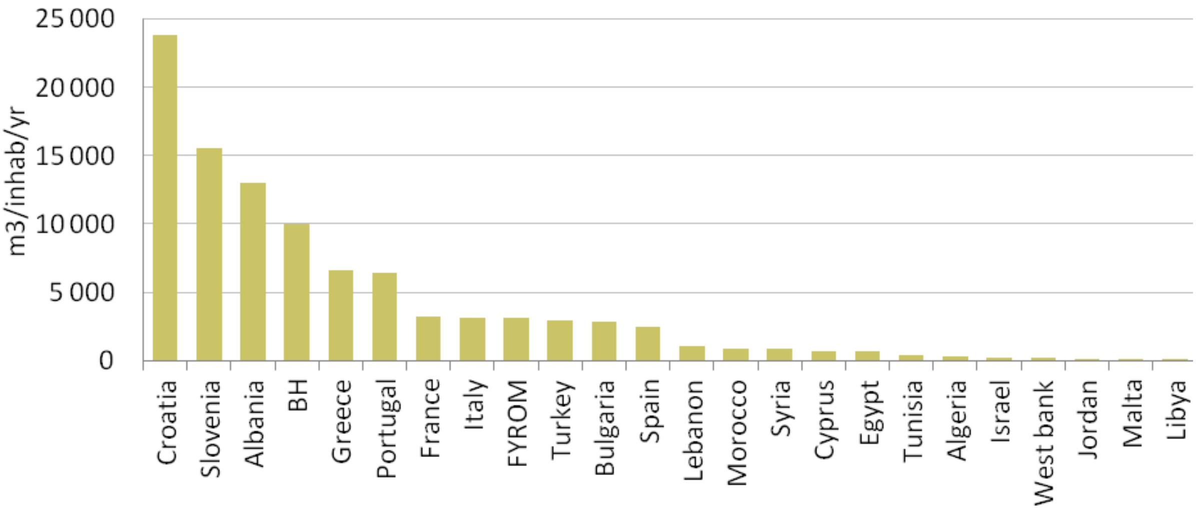


Figure 1.20. Water resources per inhabitant, Mediterranean countries, 2012
Note: BH = Bosnia and Herzegovina; FYROM = The former Yugoslav Republic of Macedonia; Syria = Syrian Arab Republic.
Source: FAOSTAT, 2012, AQUASTAT database.

The per capita availability of water, including imported quantities, shows similar disparities between NMCs and SEMCs (Figure 1.20). With the exception of Lebanon and Turkey, less than 1 000 m^3 of water is available per person per year in southern Mediterranean countries, and the value is less than 500 m^3 per person per year in six of those countries and as little as 94 m^3 per person per year in Libya. The Balkan states are in a more favourable situation, with more than 5 000 m^3 per person per year in five of the seven countries.

The water exploitation index for natural renewable freshwater resources is used to measure the relative pressure on those resources arising from their annual use (Figure 1.21). Exploitation above 40 percent of the sustainably available resource indicates a situation of severe water stress. This is the case in Egypt, Libya, Malta, Israel and the Syrian Arab Republic, where the index exceeds 80 percent. With the exception of Malta, no NMCs have an index value above 40 percent. Of the SEMCs, Turkey is the only country with an index value below 30 percent.

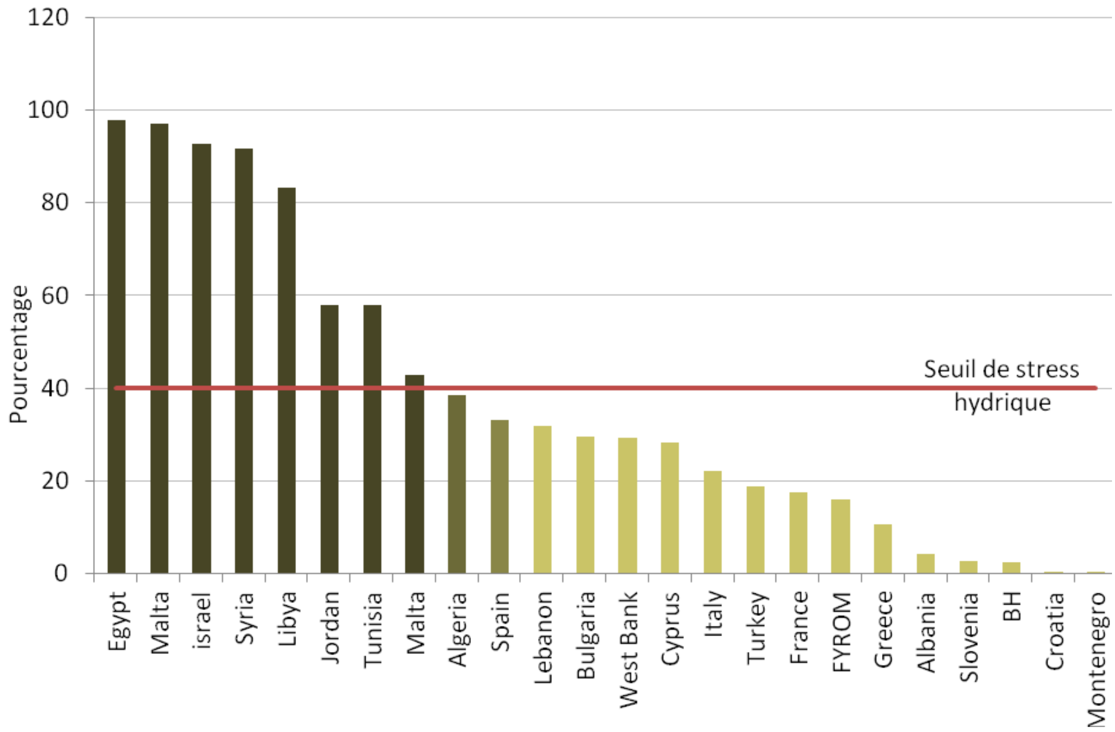


Figure 1.21. Water exploitation index for natural renewable freshwater resources in Mediterranean countries, 2012
Note: BH = Bosnia and Herzegovina; FYROM = The former Yugoslav Republic of Macedonia; Syria = Syrian Arab Republic.
Source: Plan Bleu from Ewing *et al.*, 2010.

It has been estimated that, by 2070, the area of land in the NMCs experiencing occasional water stress will have increased by 19–35 percent (Margat and Blinda, 2005). Where water demand has stabilized, efforts are focused on conservation and the use of nonconventional resources (*e.g.* wastewater treatment and desalination). In the SEMCs, where demand could increase by 18 percent by 2025 (Margat and Blinda, 2005), priorities for reducing vulnerability to water shortages include the management of demand and usage; the efficient use of water during transport and distribution, by users and in irrigation; and wastewater treatment.

Growing energy demand met mainly by fossil fuels

To meet rapidly increasing energy consumption due to the growth of both population and economies, the Mediterranean region is facing pressure in energy supply, transport and distribution. More than 80 percent of current energy demand is met by fossil fuels. Renewable energies (hydroelectricity, biomass, wind, solar and geothermal energy) represent 6.7 percent of the regional energy supply, and nuclear energy supplies the remaining 13.3 percent. In 2007, Mediterranean countries imported 35 percent of their energy needs from other regions (Figure 1.22).

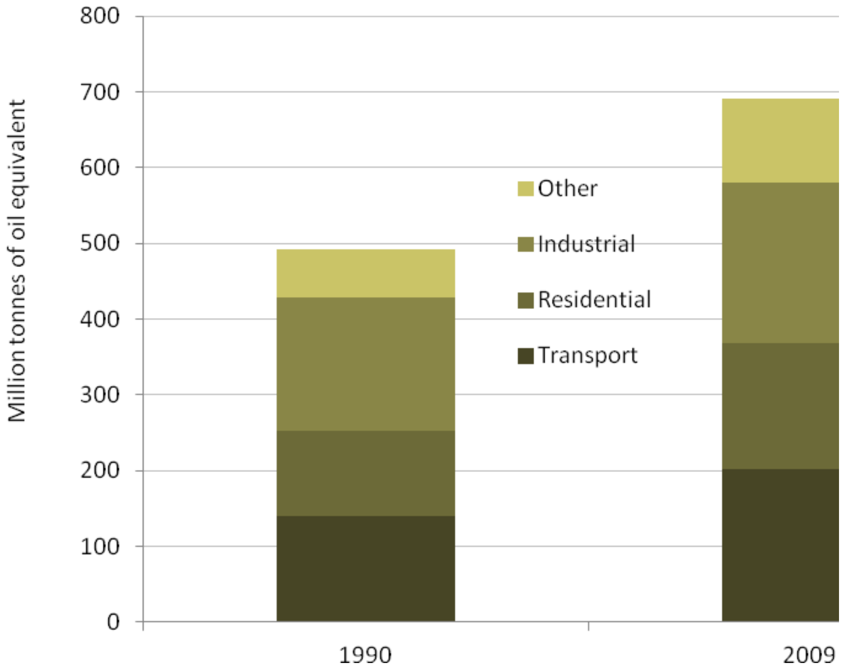


Figure 1.22. Energy consumption in the Mediterranean region, 1990 and 2009
Source: Observatoire Méditerranéen de l'Energie, 2010.

With a total consumption of 688 million tonnes of oil equivalent, per capita energy consumption in the Mediterranean region is 13 percent higher than the global average. Between 1971 and 2007, energy consumption in the region more than doubled, including a four-fold increase in the share of electricity.

The NMCs are the largest energy consumers, although the gap with the SEMCs is shrinking. The ratio of per capita energy consumption between the NMCs and the SEMCs declined from 8:1 in 1971 to 3.6:1 in 2007. Fuelwood remains an essential source of energy in the SEMCs, especially for rural people, which can cause degradation of the resource.

Net intra-Mediterranean trade reached nearly 97 million tonnes of oil, 74 billion m^3 of gas and 70 terawatts (TWh) of electricity in 2006. Oil and gas exporting countries (Algeria, Egypt, Libya and the Syrian Arab Republic) supplied 22 percent of oil and met over 35 percent of the demand for gas in France, Greece, Italy, Slovenia, Spain and Turkey. Electricity trading accounted for only a minor part of overall consumption; about one-tenth of all intra-Mediterranean trade in electricity (approximately 7.5 TWh) was between SEMCs.

Increases in energy consumption and particularly the consumption of fossil fuels was a major cause of increases in greenhouse gas emissions between 1999 and 2008 in all Mediterranean countries except Israel and Portugal (Figure 1.23). In 2008, total emissions of greenhouse gases (carbon dioxide equivalent) in the Mediterranean region were 2 487 million tonnes, a 15 percent increase over 1999. The NMCs were responsible for 63 percent of these emissions, and France, Italy and Spain alone were responsible for 48 percent. Emissions increased by 32 percent in the SEMCs over the period due to strong economic and population growth and by 7 percent in the NMCs.

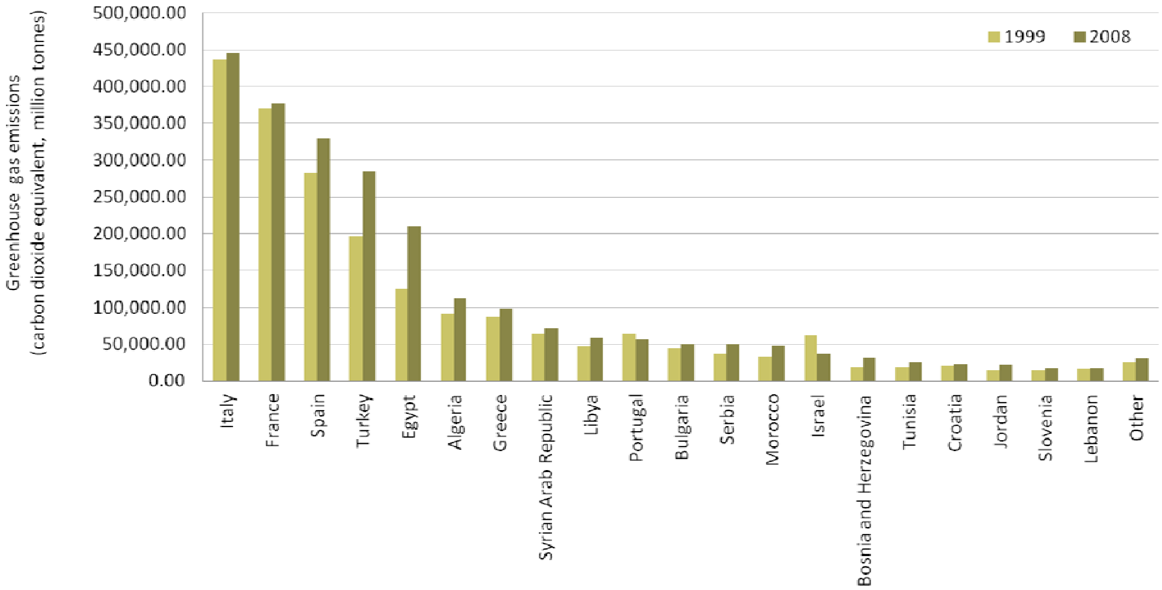


Figure 1.23. Greenhouse gas emissions, in Mediterranean countries, 1999 and 2008
Note: Other = Albania, Andorra, Cyprus, Gibraltar, Malta, Palestine, The former Yugoslav Republic of Macedonia.
Source: Observatoire Méditerranéen de l'Energie, 2010.

Soil degradation and land-use change proceed at alarming pace

Urbanization, population growth and the overexploitation of resources lead to concerns about soil degradation and the loss of arable land (Figure 1.24). Land degradation decreases agricultural productivity and compromises essential ecosystem services and is a major factor in poverty and biodiversity loss.

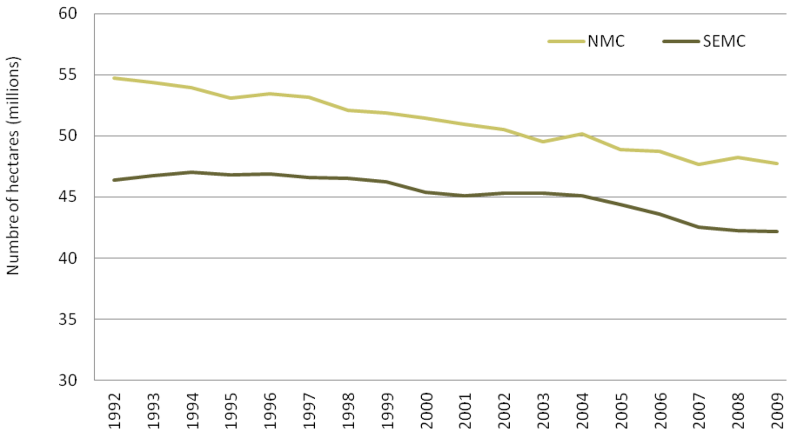


Figure 1.24. Evolution of arable lands in the Mediterranean region, 1992–2009
Source: FAOSTAT, 2012.

At the European level, a framework directive on soil protection was proposed in 2007. This directive reported that 45 percent of European soil is degraded and depleted of organic matter and noted that the problem was particularly pressing in the Mediterranean region. Degradation can involve erosion, settling, the loss of organic matter, salinization, landslides, the loss of soil biodiversity, acidification, desertification and subsidence. All these problems could be exacerbated by climate change. Between 1992 and 2009, the area of arable land decreased by 7 million hectares (13 percent) in the NMCs and by 4 million hectares (9 percent) in the SEMCs. Figure 1.25 shows that there were considerable differences between countries, with losses of arable land greater than 25 percent in Croatia, Malta, Portugal and The former Yugoslav Republic of Macedonia, and gains of between 15 percent and 20 percent in Bosnia and Herzegovina and Egypt.

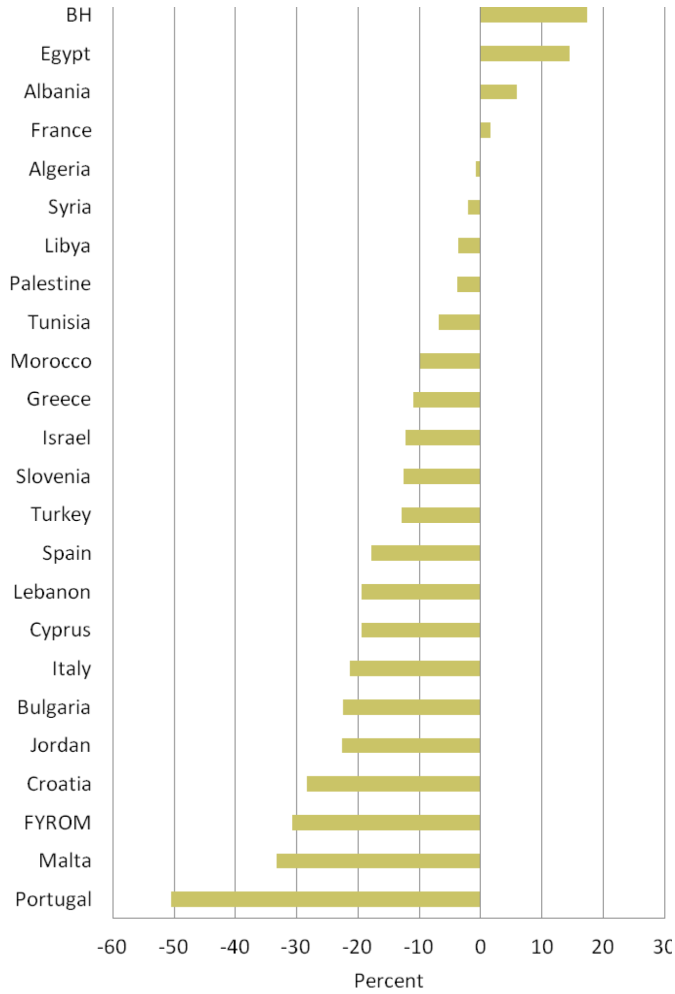


Figure 1.25. Changes in the area of arable land, Mediterranean countries, 1992 to 2009
Note: BH = Bosnia and Herzegovina; FYROM = The former Yugoslav Republic of Macedonia; Syria = Syrian Arab Republic.
Source: FAOSTAT, 2012.

In some countries there was an overall increase in arable land, although this might mask local declines. In Egypt, for example, despite an overall increase in arable land due to desert reclamation, there were irreversible losses of other lands as a result of urbanization, desertification and salinization. Overgrazing is a major cause of soil degradation in many SEMCs, exacerbated by the excessive use of fire.

Most national governments in the Mediterranean region have ratified the United Nations Convention to Combat Desertification (UNCCD, 1994) and are committed to adopting public policies and programmes to combat desertification. National Action Programmes to Combat Desertification play an important role at the national and local levels.

Climate change: aggravating existing problems

Hotter and drier. The effects of climate change can be seen in the Mediterranean and have begun to exacerbate already existing pressures and degradation phenomena and the vulnerability of ecosystems and populations that depend on them, leading to considerable and sometimes irreversible changes to the environment. Numerous essential economic activities in the region are and will be increasingly affected.

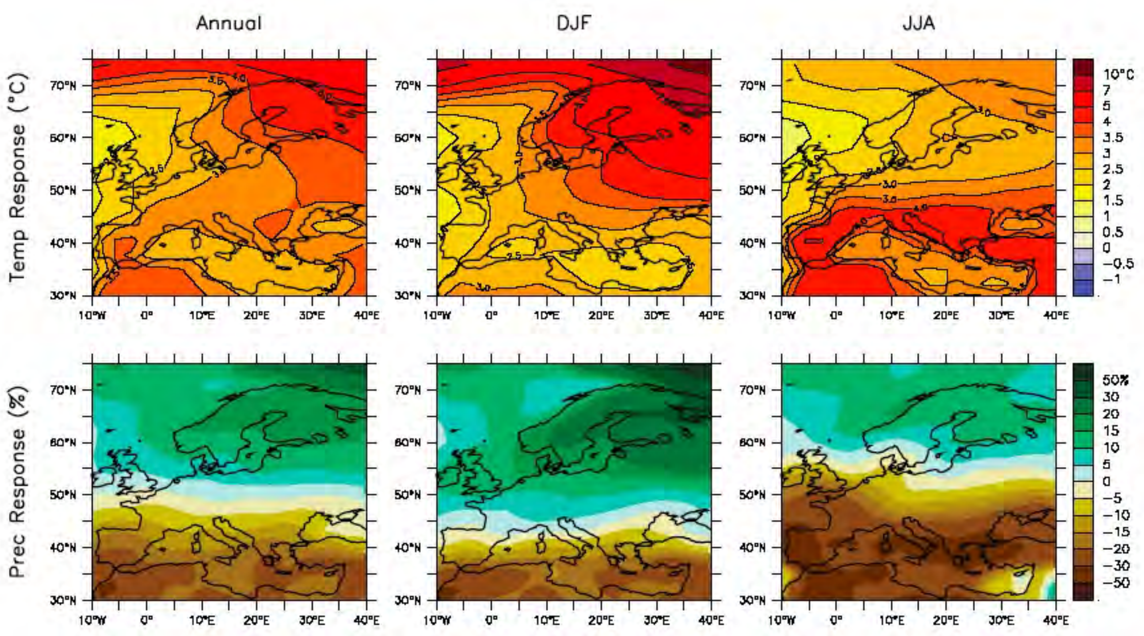


Figure 1.26. Comparison of current temperatures and rainfall, with projections for 2100
Note : DJF= December, January, February; JJA = June, July, August.
Source: IPCC, 2007b.

Global climate change affected the Mediterranean throughout the twentieth century and has clearly accelerated since 1970, with an average warming of nearly 2 °C in southwestern Europe (specifically, the Iberian Peninsula and southern France). The exception is Greece, where, until the early 2000s, the average annual temperature declined. There may also have been warming in northern Africa, although this is difficult to quantify due to a lack of data. Rainfall decreased by up to 20 percent in the twentieth century in some parts of the SEMCs (Figure 1.26 and Table 1.2).

Table 1.2. Projected changes in temperature and precipitation in the Mediterranean in 2100

	Temperature variation (°C)		Precipitation variations (°C)		Occurrence of extreme events (%)		
Season	Min	Max	Min	Max	Hot	Humid	Dry
Winter	+1.7	+4.6	-16	+6	93	3	12
Spring	+2	+4.5	-24	-2	98	1	31
Summer	+2.7	+6.5	-53	-3	100	1	42
Autumn	+2.3	+5.2	-29	-2	100	1	21
Annual	+2.2	+5.1	-27	-4	100	0	46

Source: IPCC, 2007.

Risks throughout the region, but SEMCs particularly affected. Table 1.2 shows the projected changes in temperature and precipitation in the Mediterranean region in 2100. The most significant temperature increases in the region are projected to occur in the Machrek (Egypt, Jordan, Lebanon, Palestine and the Syrian Arab Republic). There will be changes in precipitation throughout the Mediterranean region, but the projected increase in water stress in most SEMCs is alarming. Models project more frequent and serious continental droughts (fewer days of precipitation and an increase in the length of the longest periods without rain). Average annual river flow is projected to decrease, despite possible seasonal redistribution (*e.g.* more water in winter and less in spring and summer). It is also projected that extreme events will become more frequent and intense.

Such changes for human activities would have direct consequences. Hotter and drier summers and more extreme events could increase the risk of fire and flooding; add to already significant pressure on water resources, particularly for agriculture; make the region less attractive for tourism; and increase the health risks associated with high temperatures and the expansion of the habitats of tropical disease-carrying insects.

Impacts on water resources. The Mediterranean region is in a serious situation of water stress. The catchment areas of Libya, southern Spain, Tunisia and the southeast Mediterranean (Israel, Lebanon, Palestine and the Syrian Arab Republic) are most vulnerable due to limited water resources and high demand (Figure 1.27; Milano *et al.*, 2012). Moreover, these areas often use nonconventional water resources (*e.g.* desalination and wastewater treatment) and non-renewable resources (extracting from fossil aquifers) in addition to surface water (Qadir *et al.*, 2007). Basins in northern Italy, western Greece and the Ebro in Spain are in a situation of moderate water stress, while the Mediterranean parts of France and the Balkans are stable.

Figure 1.27 shows water stress projected to 2050, when climate change is projected to lead to a significant (30–50 percent) depletion of water resources in the Mediterranean region and even greater depletion in arid to semi-arid subregions (Milano *et al.*, 2012). Improvements in the efficiency of water transport and distribution networks, irrigation, use and consumption would limit overall water abstraction in the northern part of the region and in Morocco and Turkey. In the other SEMCs, however, water abstraction is still projected to double, particularly because of population growth. In the north, only the Ebro (in northern Spain), Albania and western Greece would experience moderate to severe water stress as a result of depleted water resources and an increase in agricultural water use under projected hotter and drier climatic conditions. All SEMCs are projected to experience severe water stress; despite the expected low increase in water abstraction in Morocco and Turkey due to an improvement in water distribution systems and water conservation, those two countries are projected to experience severe water stress due to a decrease in water resources.

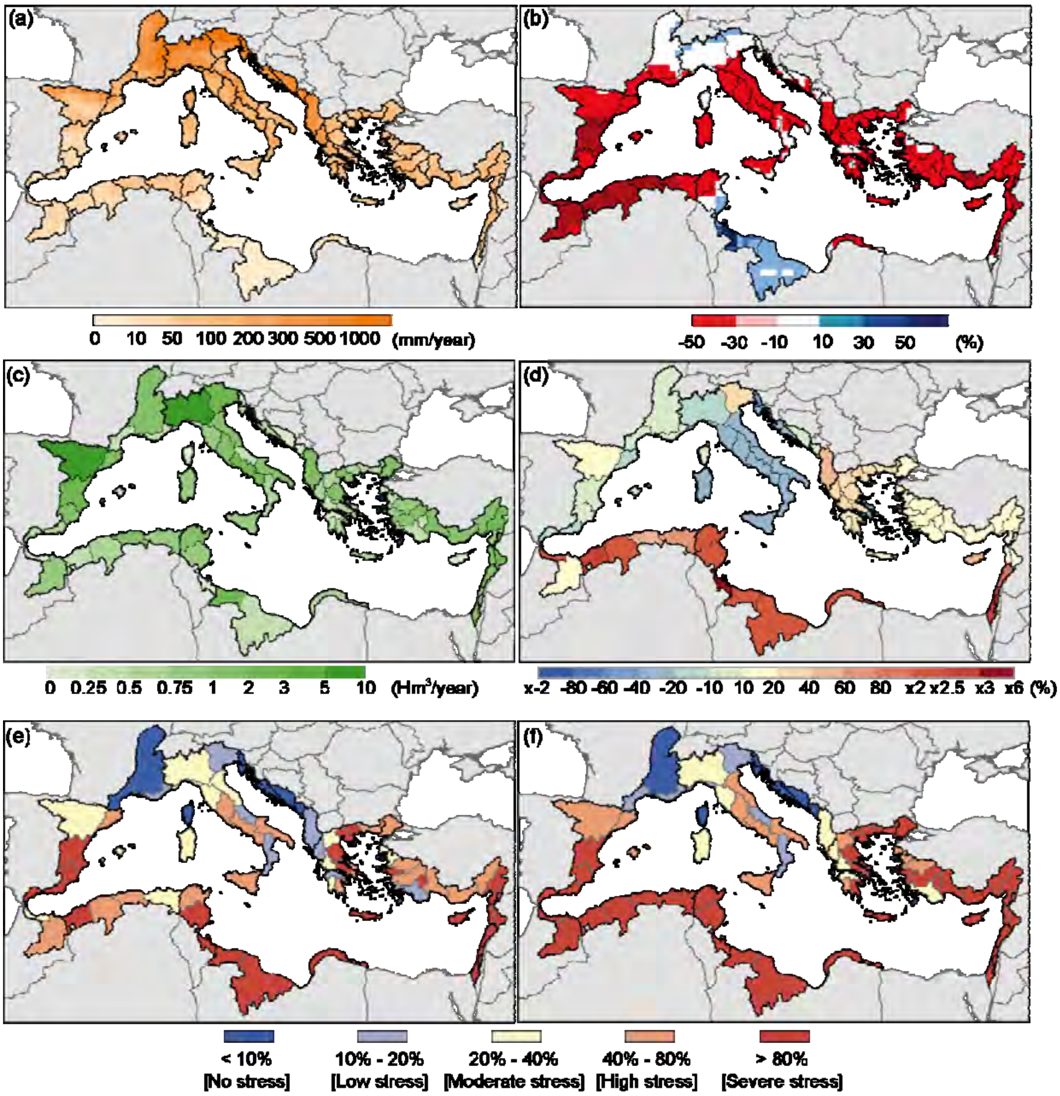


Figure 1.27. Change in water use parameters in the Mediterranean in the context of global change
Note: a = available water resources for the period 1971–1990; b = projected available water resources in 2050; c = state of water abstraction for the period 2001–2009; d = projected state of water abstraction in 2050; e = current water stress; f = projected water stress in 2050 due to climatic and anthropogenic changes; <10% = no stress; 10–20% = low stress; 20–40% = moderate stress; 40–80% = high stress; >80% = severe stress.
Source: Milano *et al.*, 2012.

Thus, while the overall situation in the NMCs may be stable, the risk is quite high in the SEMCs. In countries with the highest projected population growth and expansion of irrigated area, improvements to distribution networks and water-use practices alone will be insufficient to reduce pressure on water resources. In the medium term, under the combined effects of fewer available resources and increased use, there is likely to be an increase in water stress. The disparities between the NMCs and the SEMCs in a range of socio-economic and environmental factors are likely to intensify.

Impacts on ecosystems and biodiversity. Climate change could affect ecosystems in multiple ways, such as by reducing or expanding their extent and distribution, changing the behaviour of species and their interactions, and changing the risk of pressures such as fire, diseases and species' invasions.

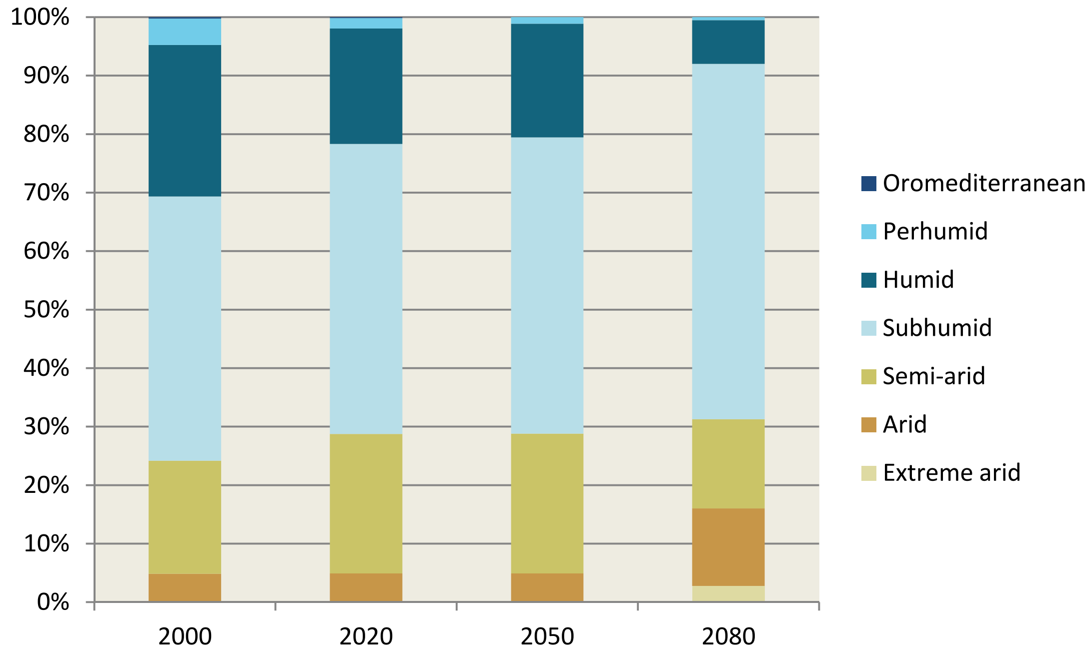


Figure 1.28. Bioclimatic areas in Lebanon
Source: Samir Safi, Lebanese University, Beirut, 2004.

Rising temperatures cause vegetation to displace in latitude and altitude. In the Mediterranean region, it is estimated that a 1 °C increase in temperature could cause certain plant species to migrate approximately 180 km to the north or 150 m in altitude (Plan Bleu, 2009), as well as alter the distribution of pathogenic species and their vectors. Combined with periods of more severe drought, warming could lead to an increased frequency of fire, which may hinder the regeneration of species and lead to accelerated desertification. Such changes could increase the risk of extinction of a wide range of species and ecosystems.

A number of studies predict changes in certain environments. Safi (2004), for example, predicted changes in bioclimatic areas in Lebanon by 2080 and suggested that there would be an expansion of arid zones and a contraction of cooler and more humid zones (Figure 1.28). Forecasts made within the framework of the CARBOFOR project (Badeau *et al.*, 2005) suggest that, in France, areas favourable to mountain forest and northern species will be lost by 2100, while areas favourable to species adapted to hotter and drier conditions will expand (Figure 1.29).

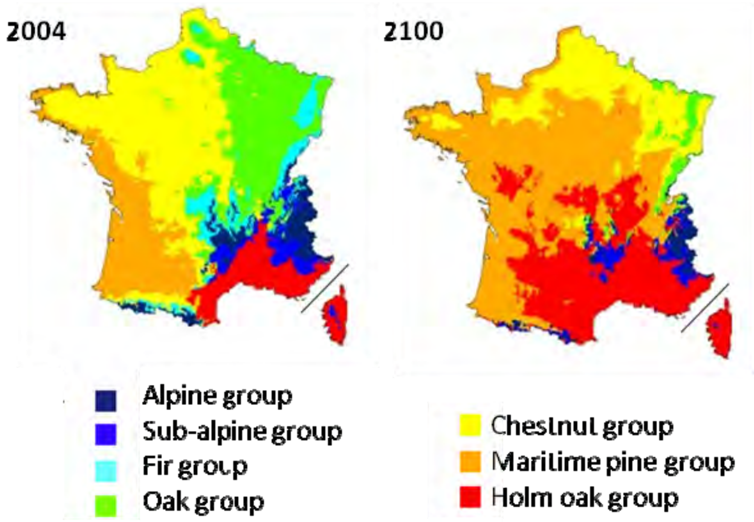


Figure 1.29. Predicted changes in the ranges of forest species groups in France, 2004–2100
Source: Loustau, 2004.

Within a population, the effects of climate change on seasonal thermal and pluviometric variables also cause phenological modifications. Some behavioural adaptations in certain species to temporal phenomena that are favourable to growth, regeneration or reproduction could become obsolete; for example, a change in the timing of plant flowering could reduce the availability of pollinators. The metabolism of species could also be affected, with possible implications for carbon sequestration, for example. Carbon storage by vegetation, which mainly takes place during periods where there is sufficient precipitation and water in the soil, could decrease. The capabilities and pace of adaptation and movement are specific to species and are also limited by pedoclimatic factors, the fragmentation of habitats and the availability of colonizable space. The rate of species' extinctions could therefore accelerate and endemic species are likely to be particularly affected.

2

State of forest resources in the Mediterranean region

2.1 Assessment of forest resources in the Mediterranean region

Forests have always played an important role in Mediterranean culture. For a very long time, Mediterranean forests have been appreciated and exploited for the multiple goods and services they provide. However, overexploitation has had negative effects on the environment and is responsible for degradation in many Mediterranean forests.

The situation differs across the region. In the northern Mediterranean, forests are often abandoned, whereas in the south and east, anthropogenic pressures contribute to land degradation. In both cases, forest benefits are under threat, and new strategies are required to sustainably manage these fragile ecosystems.

This report considers the Mediterranean region as comprising the countries surrounding the Mediterranean Sea. A Mediterranean climate is one characterized by mild winters and hot and dry summers, with precipitation concentrated in autumn, winter and early spring. Total rainfall varies strongly from year to year and violent precipitation events or dry winds can occur. The winter temperature occasionally falls below 0 °C at sea level, and snow and below-zero temperatures are common at high altitudes (*e.g.* the Alps, the Pyrenees and the North African range).

Mediterranean forests, woodlands and shrub vegetation are common in the thermo-Mediterranean and Meso-Mediterranean belts, which occur at low elevations. At higher altitudes, other forest types colonize the supra-Mediterranean, montane-Mediterranean and oro-Mediterranean zones (Quézel, 1985). At yet higher elevations, forests may comprise endemic Mediterranean trees as well as tree species from other parts of the European continent (*e.g. Fagus sylvatica* and *Castanea sativa* with *Pinus laricio*, *P. leucodermis*, *P. sylvestris*, *Abies alba,* Mediterranean firs and *Cedrus* species) (Scarascia-Mugnozza *et al.*, 2000).

Typical Mediterranean forests are composed of broadleaved species (mainly oaks), both evergreen and deciduous, such as *Quercus ilex*, *Q. suber*, *Q. coccifera*, *Q. pubescens*, *Q. cerris*, *Q. pyrenaica*, *Q. toza*, *Q. calliprinos*, *Q. ithaburensis* and others, and conifers such as *P. halepensis*, *P. brutia*, *P. pinea*, *P. pinaster* and *Juniperus* species. The degradation of such forests has produced low-density woody vegetation known as the *macchia* and the *garrigue*. Where there is no water limitation (*e.g.* along rivers), forests of *Q. robur, Q. petraea, Fraxinus* species*, Populus alba* and *P. nigra* can prosper. Typical of the Iberian Peninsula, the *dehesa* is characterized by pastures with scattered oaks, both evergreen and deciduous, sometimes mixed with *Pinus pinea*. The vegetation in the Xerothermo-Mediterranean zone comprises mainly shrub communities. Non-endemic species introduced over the course of the centuries may also be found in Mediterranean forests.

Many Mediterranean countries also have areas that do not have a typically Mediterranean climate: for example, northern countries such as France, Italy, Spain and Turkey have substantial temperate areas, while many southern countries have large deserts. This chapter covers all forest areas in the Mediterranean region, focusing wherever possible on forests growing in a Mediterranean climate. It gives an overview of the state of forests in Mediterranean countries based on available data.

Extent of forest resources

Forest area

In 2010, the estimated forest area in Mediterranean countries was over 85 million hectares (ha), representing 2 percent of the world's forest area (4 033 million ha; FAO, 2010b). This forest is distributed unevenly over the Mediterranean basin, with significant differences between countries (Figure 2.1). For example, Spain, France and Turkey account for more than 50 percent of the total forest area (Table 2.1). Other wooded lands (OWLs) represent only 4 percent of the total Mediterranean land area, although they comprise 20 percent, 19 percent and 13 percent of the total land area in Greece, Spain and Turkey, respectively (Table 2.1).

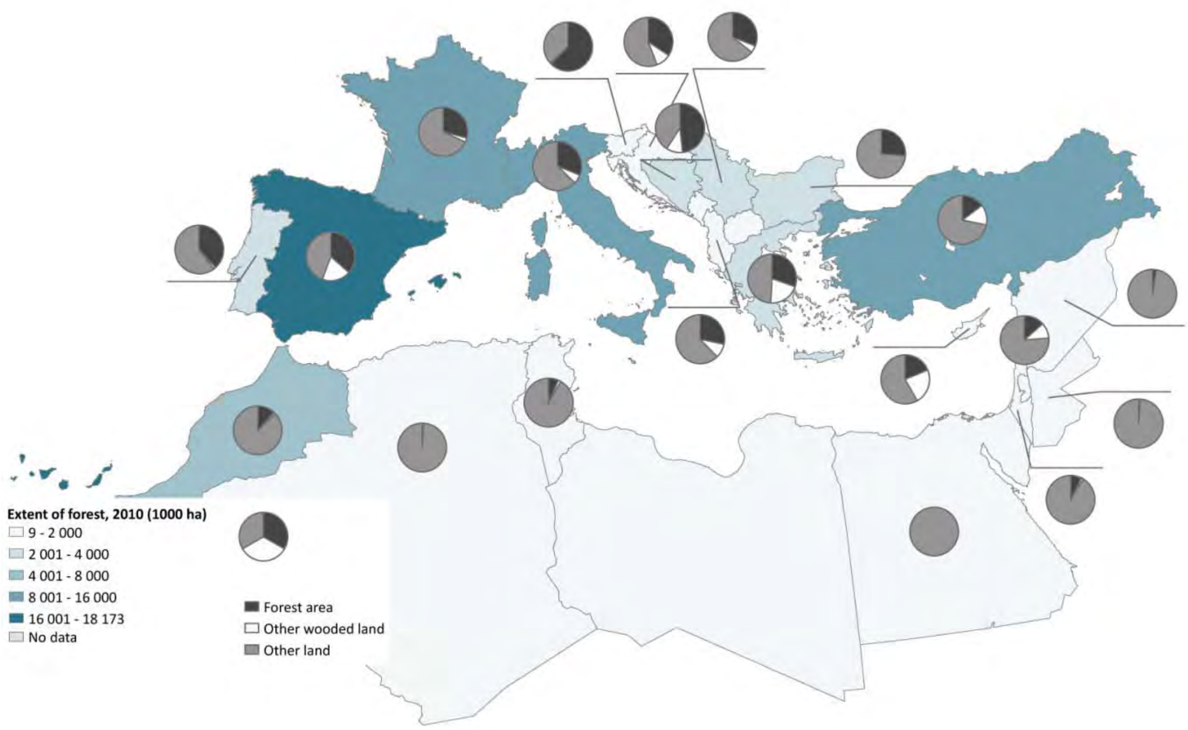


Figure 2.1. Extent of forest area in Mediterranean countries, 2010
Source: FAO, 2010b.

Table 2.1. Forest area in Mediterranean countries

Country	Land area (1 000 ha)	Forest		Other wooded land		Other land		% of total forest area in Mediterranean countries
		1 000 ha	% of land area	1 000 ha	% of land area	1 000 ha	% of land area	
Spain	49 919	18 173	36	9 574	19	37 438	68	21
France	55 010	15 954	29	1 618	3	55 261	72	19
Turkey	76 963	11 334	15	10 368	13	18 495	63	13
Italy	29 411	9 149	31	1 767	6	38 868	87	11
Morocco	44 630	5 131	11	631	1	6 937	64	6
Bulgaria	10 864	3 927	36	0	0	6 351	49	4.6
Greece	12 890	3 903	30	2 636	20	5 457	60	4.6
Portugal	9 068	3 456	38	155	2	5 623	64	4.0
Serbia	8 746	2 713	31	410	5	2 099	41	3.2
Bosnia and Herzegovina	5 120	2 472	48	549	11	3 118	56	2.9
Croatia	5 592	1 920	34	554	10	233 997	98	2.2
Algeria	238 174	1 492	1	2 685	1	740	37	1.7
Slovenia	2 014	1 253	62	21	1	14 230	92	1.5
Tunisia	15 536	1 006	6	300	2	1402	55	1.2
The former Yugoslav Republic of Macedonia	2 543	998	39	143	6	1 709	62	1.2
Albania	2 740	776	28	255	9	17 852	97	0.9
Syrian Arab Republic	18 378	491	3	35	0.002	638	46	0.6
Montenegro	1 382	467	34	277	20	175 407	100	0.5
Libya	175 954	217	0.001	330	0.002	537	58	0.3
Cyprus	924	173	19	214	23	1 977	91	0.2
Israel	2 164	154	7	33	2	780	76	0.2
Lebanon	1 023	137	13	106	10	8 675	98	0.2
Jordan	8 824	98	1	51	1	99 455	100	0.1
Egypt	99 545	70	0.0007	20	0.0002	29	64	0.1
Others	686	25	4	0	0	632	92	0.1

Note: Others = Andorra, Gibraltar, Holy See, Malta, Monaco, Palestine and San Marino.
Source: FAO, 2010b.

The forest area of the Mediterranean region increased by almost 12 million ha between 1990 and 2010, an average rate of 0.68 percent per year. Only Albania, Algeria, Bosnia and Herzegovina and Israel had periods of net forest loss (FAO, 2010b) (Figure 2.2).

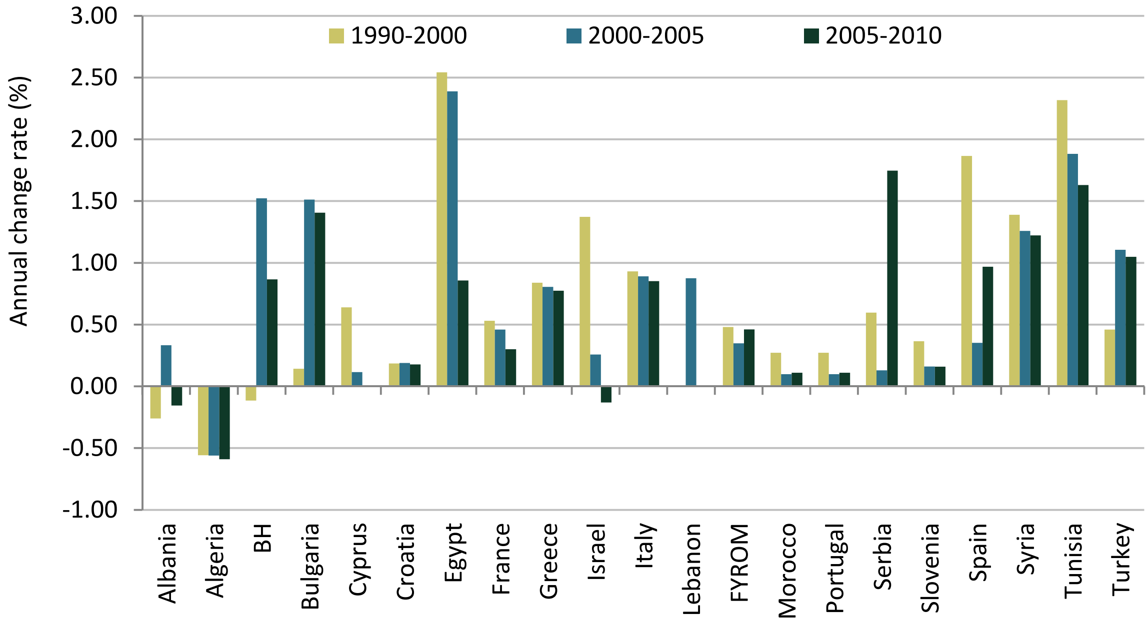


Figure 2.2. Annual rate of change in forest area by Mediterranean country, 1990–2010
Note: BH = Bosnia and Herzegovina; FYROM = The former Yugoslav Republic of Macedonia; Syria = Syrian Arab Republic
Source: FAO, 2010b.

Growing stock

Growing stock (i.e. the stem volume of living trees) is a basic variable in forest inventory and in most countries forms the basis of estimates of biomass and carbon stock. In 2010, the estimated total forest growing stock in the countries of the Mediterranean region was 9 623 million m^3, of which 4 062 million m^3 (41 percent) was conifers and 5 550 million m^3 (58 percent) was broadleaved species.

Bulgaria, France, Italy, Spain and Turkey had the highest volume of growing stock (more than 500 million m^3 each) (Figure 2.3). There were large differences in growing stock per ha between countries: in Croatia and Slovenia, growing stock was greater than 200 m^3 per ha, while the lowest values of growing stock per ha were in Israel, Jordan, Lebanon, Libya, Morocco and Tunisia, where water scarcity, poor soils and climatic conditions limit tree growth (Table 2.2). Non-Annex I countries of the United Nations Convention on Climate Change (Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Palestine, the Syrian Arab Republic and Tunisia) contributed only 4 percent of the total growing stock in the Mediterranean region in 2010 (Figure 2.4).

On average, the total growing stock in the Mediterranean region increased by 1.09 percent per year between 1990 and 2010, a total expansion over the period of more than 2 billion m^3.

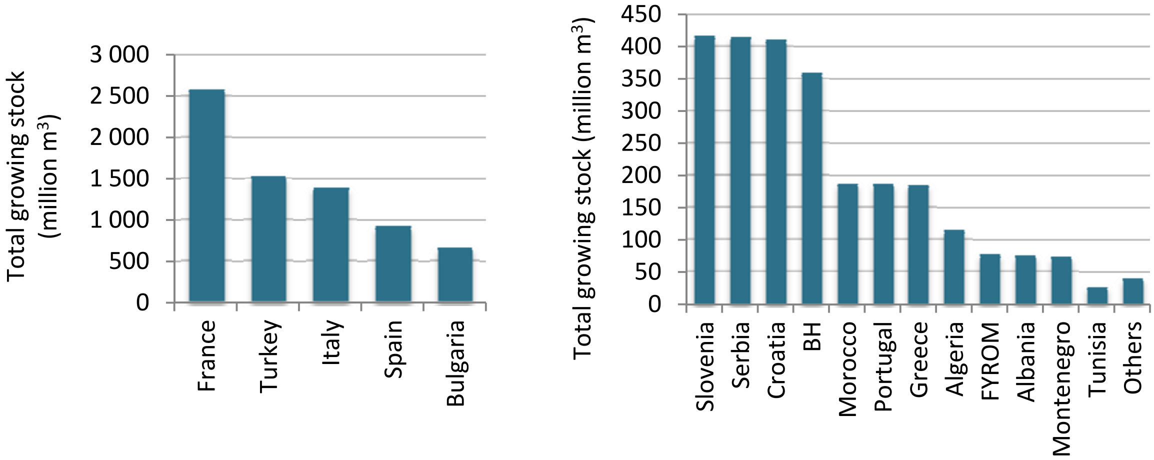


Figure 2.3. Growing stock of forests in countries of the Mediterranean region, 2010
On the right: Mediterranean countries with growing stock greater than 500 million m^3. On the left: Mediterranean countries with growing stock less than 500 million m^3.
Note: "Others" = Cyprus, Egypt, Israel, Lebanon, Libya, Jordan, Malta, Gibraltar, Holy See, Monaco, San Marino, Palestine, Syrian Arab Republic. BH = Bosnia and Herzegovina; FYROM = The former Yugoslav Republic of Macedonia.
Source: FAO, 2010b

Table 2.2. Forest growing stock, per hectare, some Mediterranean countries, 2010

Country	Growing stock per hectare (m^3)
Slovenia	332
Croatia	213
Bosnia and Herzegovina	164
Bulgaria	167
France	162
Serbia	153
Italy	151
Turkey	135
Montenegro	133
Egypt	120
Albania	97
FYROM	77
Algeria	76
Portugal	54
Cyprus	51
Spain	50
Greece	47
Israel	38
Lebanon	37
Libya	36
Morocco	36
Jordan	30
Tunisia	26

Source: FAO, 2010b.

Little information on growing stock in OWLs is available for Mediterranean countries. Algeria, Italy and Turkey contain an estimated 85 percent of the total OWL growing stock.

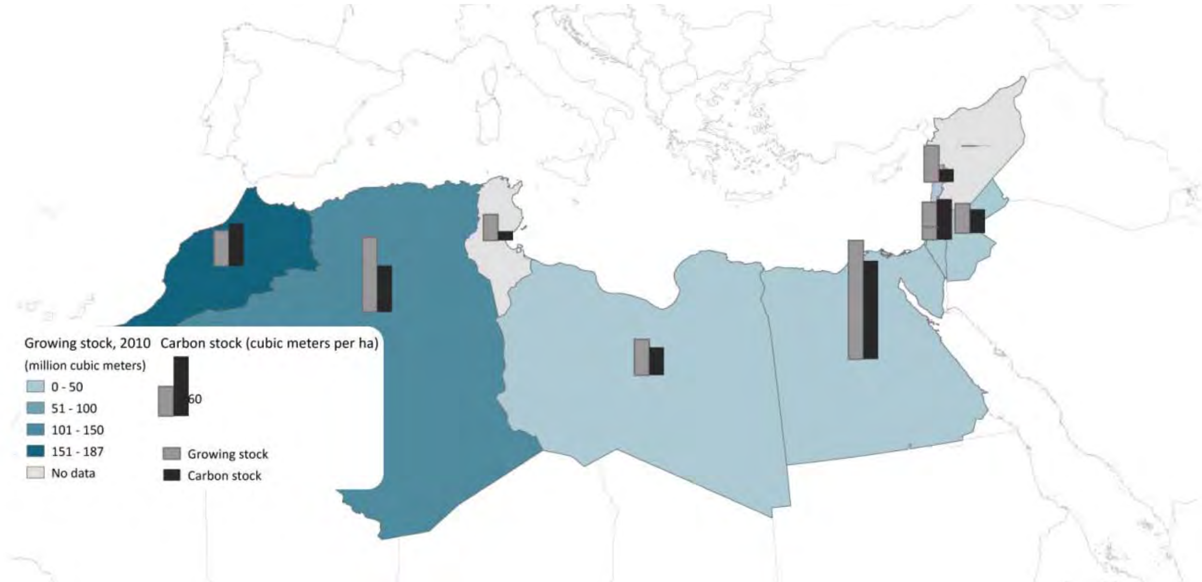


Figure 2.4. Growing stock and carbon stock in non-Annex I countries of the Mediterranean region, 2010
Source: FAO, 2010b.

Biomass

Forest biomass (*i.e.* the dry weight of living organisms; FAO, 2010b) is an important measure of ecosystem productivity. It is used in quantifying the role of forests in the carbon cycle and the potential of woody biomass for energy production.

Table 2.3 shows that, in 2010, the estimated total biomass in countries of the Mediterranean region exceeded 10 billion tonnes. Despite the lack of information on OWLs, available data indicated that 95 percent of the total biomass is in forests and 5 percent is in OWLs. The total stock of biomass increased by about 2 billion tonnes in the period 1990–2010, due mainly to an overall increase in forest area. An increase in woody biomass is not always the result of good forest management: it can also be a consequence of the abandonment of forests and rural areas, especially in northern Mediterranean countries, and can increase the risk of wildfire. In the Mediterranean region, forest fire causes severe damage, and biomass reduction may be an appropriate treatment to decrease the risk of wildfire.

Table 2.3. Biomass stock in forests and other wooded lands, Mediterranean countries, 1990, 2000, 2005 and 2010

Country	Forest, 2010 Above-ground biomass Million tonnes	Below-ground biomass	Dead wood	OWLs, 2010 Above-ground biomass	Below-ground biomass	Dead wood	Total biomass in forests 1990	2000	2005	2010	Total biomass in OWLs 1990	2000	2005	2010
Albania	74.1	23.6	..	7.8	22	..	98.4	98.6	96.6	97.7	28.8	33.4	23.4	29.8
Algeria	120	29	..	7.2	3.4	..	166	158	154	149	8.1	9.4	10	10.6
Bosnia and Herzegovina	190.2	45.6	..	..	..	..	191.7	235.8	235.8	235.8	0	0	0	0
Bulgaria	337	93	..	..	..	..	269	343	387	430	0	0	0	0
Croatia	412.6	125.8	..	28.4	14.9	..	403.6	471.1	504.8	538.4	21.7	32.6	38	43.3
Cyprus	4.6	1.5	..	..	..	..	5.1	5.4	5.8	6.1	0	0	0	0
Egypt	11.8	3.1	2.1	0.3	0.1	0.1	10.6	14.2	16.2	17	0.5	0.5	0.5	0.5
France	1979	564	..	..	..	..	2032	2207	2454	2543	0	0	0	0
Greece	132	37	..	..	..	..	143	156	162	169	0	0	0	0
Israel	7.5	1.8	0.1	..	..	..	9.6	9.2	9.3	9.4	0	0	0	0
Italy	952.2	234.8	36.8	48.4	11.4	..	823.4	1 023.7	1 123.7	1 223.8	51.8	55.8	57.8	59.8
Jordan	3.5	1.5	0.7	..	..	..	5.7	5.7	5.7	5.7	0	0	0	0
Lebanon	2.9	0.8	0	0.3	0.1	0	0	0	3.6	3.7	0	0	0.4	0.4
Libya	10.7	2.2	1.8	2.7	0.9	0.7	14.7	14.7	14.7	14.7	4.3	4.3	4.3	4.3
Malta	0.1	0	..	0	0	0	0.1	0.1	0.1	0.1	0	0	0	0
Montenegro	49.3	17.3	10.5	..	..	..	77.1	77.1	77.1	77.1	0	0	0	0
Morocco	363	111	..	0.3	0.1	..	404	451	477	474	0.1	0.3	0.4	0.4
Portugal	154	63.7	..	..	..	..	0	0	216.3	217.7	0	0	0	0
San Marino	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Slovenia	277.9	78.8	11.6	0.8	0.2	0	239.1	290.2	328.6	368.3	2.3	2	1.5	1
Spain	669.8	227.7	..	..	..	..	615.2	842.8	850.1	897.5	0	0	0	0
The former Yugoslav Republic of Macedonia	102	26.5	0.9	..	..	..	127.8	132.3	128.7	129.4	0	0	0	0
Tunisia	14	4.9	..	0.5	0.2	..	12.4	16.1	17.5	18.9	1.2	1.1	0.9	0.7
Turkey	1 301.7	350	13	272.7	114.6	2.7	1 390	1 503.6	1 584.1	1 664.7	0	0	382.5	390

Source: FAO, 2010b.

Carbon stock

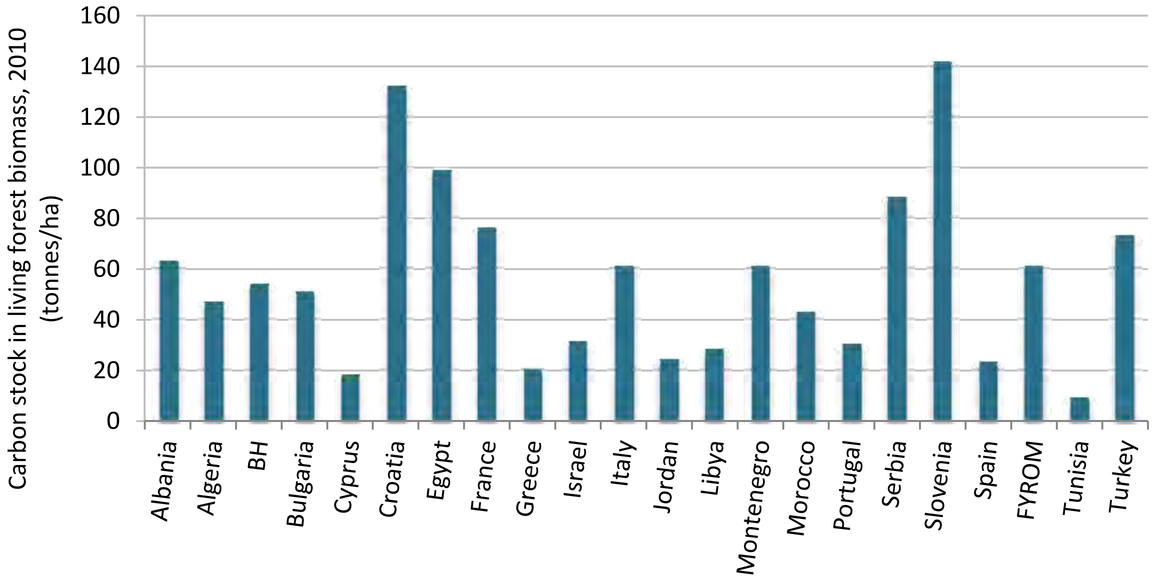


Figure 2.5. Carbon stock in living forest biomass, Mediterranean countries, 2010
Note: BH = Bosnia and Herzegovina; FYROM = The former Yugoslav Republic of Macedonia.
Source: FAO, 2010b.

Trees sequester carbon in biomass while growing, and forests therefore contain large stocks of carbon in dead organic matter, soil and biomass. The total amount of forest carbon can either increase or decrease (or stay constant), depending on forest management practices and climatic conditions. Forests can therefore mitigate or contribute to climate change by being either a sink for, or a source of, atmospheric carbon.

In 2010, forests in the Mediterranean region stocked almost 5 billion tonnes of carbon, which was 1.6 percent of global forest carbon (289 billion tonnes; FAO, 2010b). Between them, France, Italy, Spain and Turkey stored 65 percent of the total forest carbon stock in the Mediterranean region (figures 2.5 and 2.6).

The forest carbon stock in the Mediterranean region increased by about 1.2 billion tonnes between 1990 and 2010, a rate of increase of 1.3 percent per year. This was in contrast to an overall global decrease in world forest carbon stock in the same period.

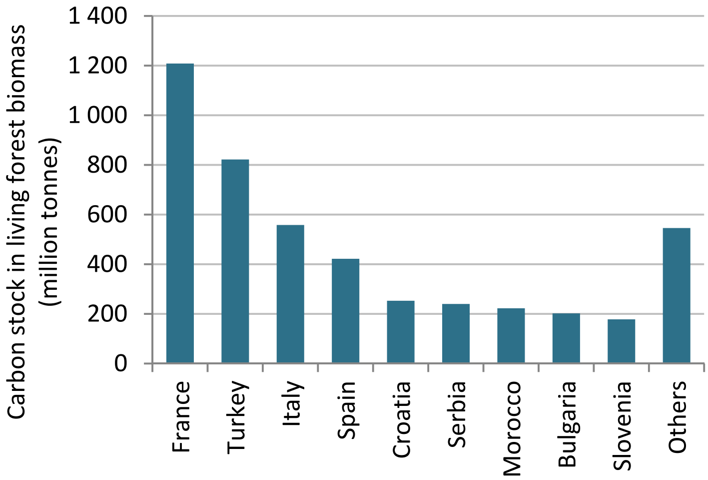


Figure 2.6. Carbon stock in Mediterranean countries, 2010
Note: Others = Albania, Algeria, Bosnia and Herzegovina, Cyprus, Egypt, Greece, Israel, Jordan, Lebanon Libya, Montenegro, Portugal, The former Yugoslav Republic of Macedonia and Tunisia.
Source: FAO, 2010b.

Forest biodiversity in the Mediterranean region

Forest biodiversity is “the variability among forest living organisms and the ecological processes of which they are part; this includes diversity in forests within species, between species and of ecosystems and landscapes” (CBD, 2001). The assessment of biodiversity can help in identifying the effects of management practices on biodiversity and in modifying such practices if necessary.

Area of primary and planted forests

FAO (2010) defined primary forests as forests of native species in which there are no clearly visible indications of human activity and where the ecological processes have not been significantly disturbed. Primary forests are often equated with high levels of biodiversity.

In 2010 there were an estimated 1.67 million ha of primary forests in the Mediterranean region, which was 2 percent of the total forest area. Figure 2.7 shows that there were large differences between countries. Turkey accounted for 58 percent of the total primary forest area in the Mediterranean region and Bulgaria for 20 percent (Figure 2.8). Overall, primary forest increased by 485 000 ha in the region in the period 1990 to 2010. Data for 1990 were only available for 11 countries, however, of which only Bulgaria, Slovenia and Turkey showed increases over the period.

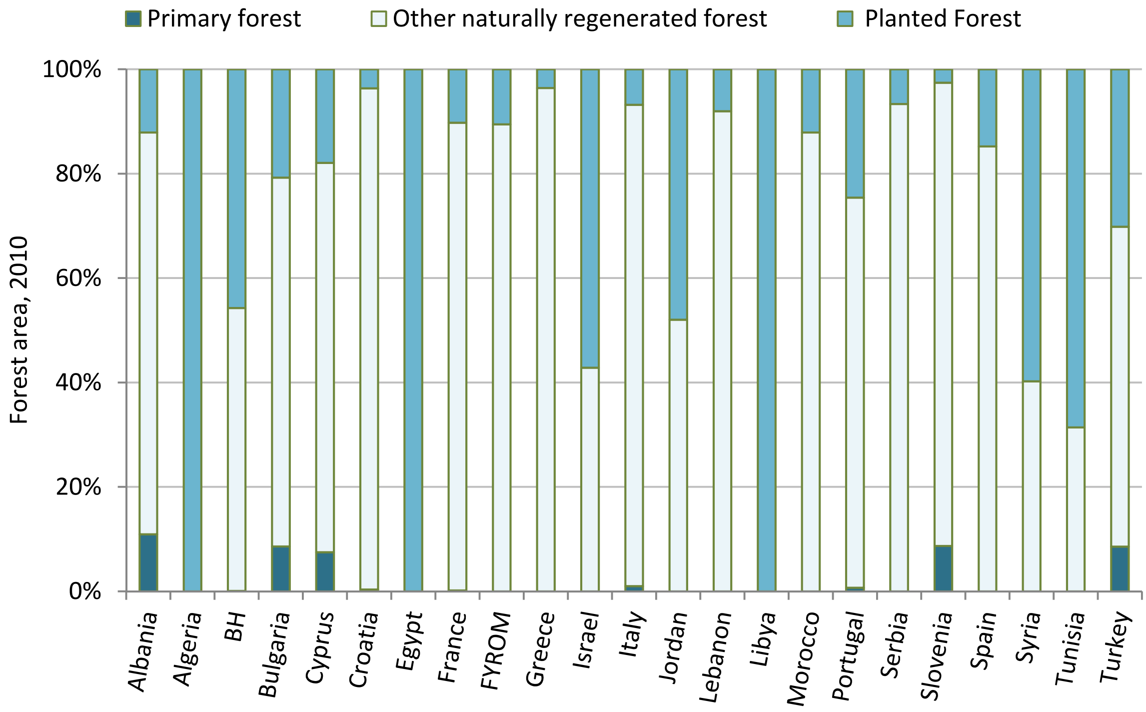


Figure 2.7. Extent of primary forests, planted forests and other naturally regenerated forests, Mediterranean countries, 2010
Note: BH = Bosnia and Herzegovina; FYROM = The former Yugoslav Republic of Macedonia; Syria = Syrian Arab Republic.
Source: FAO, 2010b.

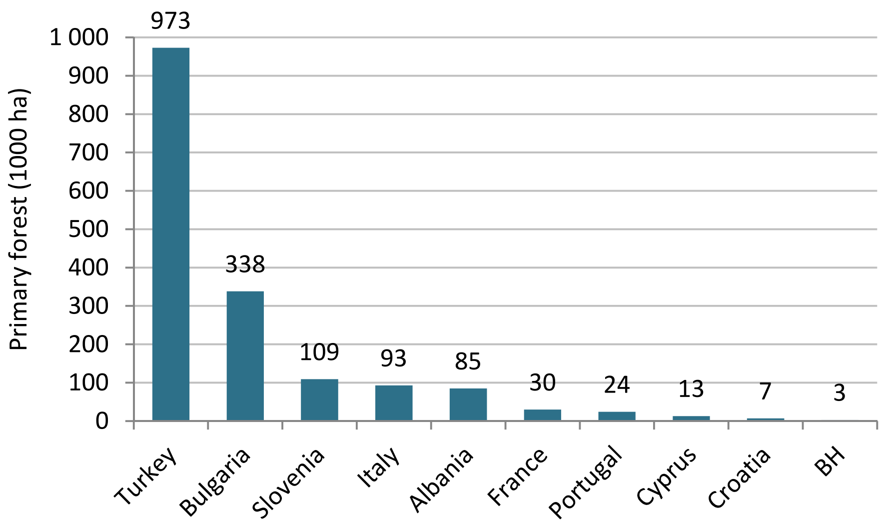


Figure 2.8. Primary forest area, ten Mediterranean countries, 2010
Note: Other Mediterranean countries have no primary forests or data were unavailable. BH = Bosnia and Herzegonvina.
Source: FAO, 2010b.

The planted forest estate in the Mediterranean region is more than 14 million ha (Table 2.4), nearly 60 percent of which is in France, Spain and Turkey. Planted forests comprise the total forest estates in Egypt, Libya and Malta and more than 50 percent of the forest estates in Israel, the Syrian Arab Republic and Tunisia (Figure 2.7). The total extent of planted forests in the Mediterranean region increased by 4.05 million ha between 1990 and 2010, due mainly to increases in Portugal, Spain and Turkey (FAO, 2010b).

Table 2.4. Trends in extent of planted forests, Mediterranean countries, 1990–2010

Country	Area of planted forest (1 000 ha)			
	1990	2000	2005	2010
Albania	103	96	98	94
Algeria	333	345	370	404
Bosnia and Herzegovina	1 047	999	999	999
Bulgaria	1 032	933	874	815
Croatia	92	81	76	70
Cyprus	24	28	29	31
Egypt	44	59	67	70
France	1 539	1 593	1 608	1 633
Greece	118	129	134	140
Israel	66	88	88	88
Italy	547	584	602	621
Jordan	..	..	47	47
Lebanon	..	..	10	11
Libya	217	217	217	217
Morocco	478	523	561	621
Portugal	..	776	812	849
Serbia	39	39	39	180
Slovenia	34	36	37	32
Spain	2 038	2 505	2 550	2 680
Syrian Arab Republic	175	234	264	294
The former Yugoslav Republic of Macedonia	105	105	105	105
Tunisia	293	519	606	690
Turkey	1 778	2 344	2 620	3 418

Note: Other Mediterranean countries did not provide data or the area of planted forests was insignificant.
Source: FAO, 2010b.

Extent of forests for the conservation of biodiversity

In 2010, almost 8.5 million ha of forests in the Mediterranean region were designated for the conservation of biodiversity, which was 10 percent of the total forest area. On average, the area of forest designated for the conservation of biodiversity increased by 3 percent per year in the period 1990–2010 (FAO, 2010b) (Figure 2.9).

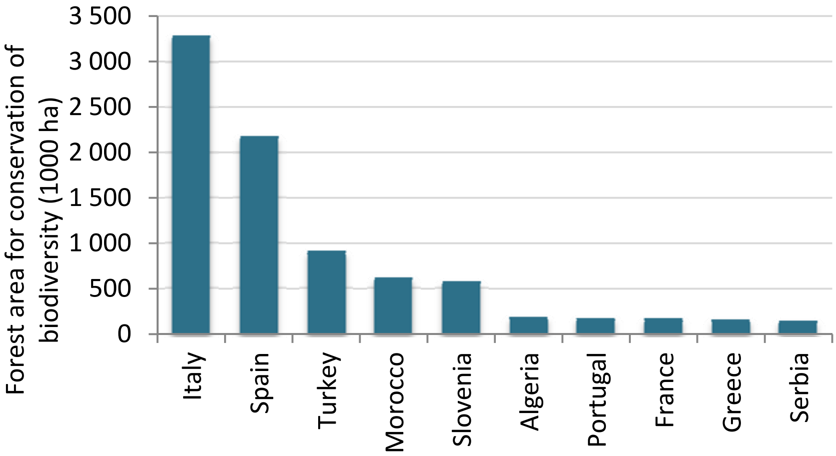


Figure 2.9. Forest area dedicated to the conservation of biological diversity, Mediterranean region, 2010
Note: Countries not shown dedicated less than 100 000 ha of forests to the conservation of biological diversity.
Source: FAO, 2010b.

Extent of forests in protected areas

Some protected areas may be designated and managed for reasons other than the conservation of biological diversity (*e.g.* the protection of soil and water resources or cultural heritage), thus the area of forest designated for the conservation of biodiversity is not necessarily equivalent to the area of forest in protected areas. In addition, forests not forming part of a protected area network may be designated for the conservation of biodiversity.

Data on the area of forests in protected areas were available for 21 countries in the Mediterranean region (representing 96 percent of the total forest area in the region). In 2010, there were more than 18 million hectares of forest in protected areas in those countries, of which Italy and Spain accounted for more than 50 percent (Figure 2.10). The area of forest in protected areas in the 21 countries increased by about 6 million ha in the period 1990–2010, an average annual increase of 3.2 percent.

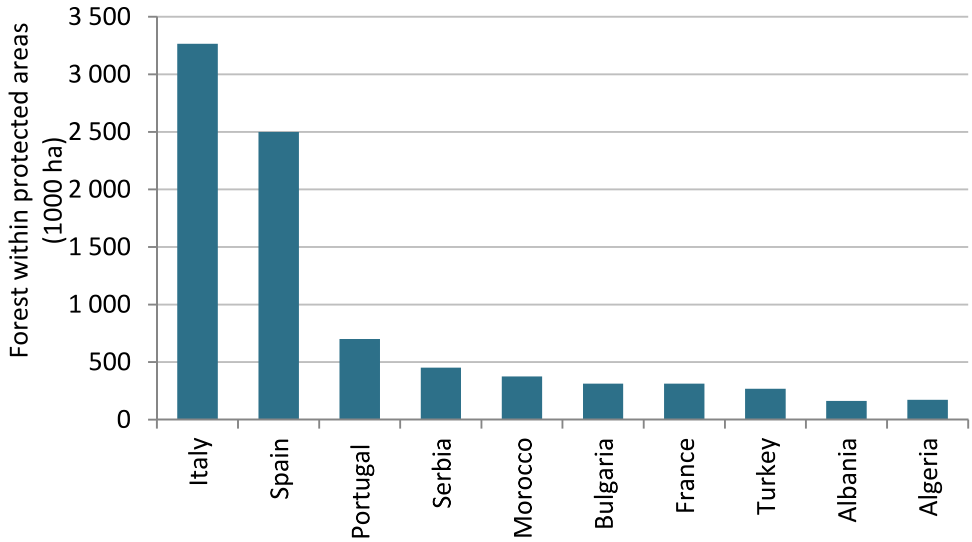


Figure 2.10. Ten Mediterranean countries with the largest forests in protected areas, Mediterranean region, 2010
Source: FAO, 2010b.

Estimating the area of Mediterranean forests

Many Mediterranean countries contain areas that do not have a typically Mediterranean climate. Here, the area of Mediterranean forest (*i.e.* forest growing in a typically Mediterranean climate) was estimated according to:

- European forest types (European Environment Agency, 2006);
- the FAO Global Forest Resources Assessment remote sensing survey (FAO and JRC, 2012).

European forest types

A forest type is “a category of forest defined by its composition, and/or site factors (locality), as categorized by each country in a system suitable to its situation” (The Montreal Process, 1998). The classification of forest by type is a key tool for improving the assessment and monitoring of forest biodiversity in Europe. It is a flexible approach to collecting and organizing information on forests in a specific region and enables a Europe-wide comparison of forests growing in similar ecological conditions and levels of anthropogenic modification, independent of country boundaries (European Environment Agency, 2006).

For this report, three main European forest types were selected based on general descriptions of the categories in terms of dominant forest species and biogeographical and ecological factors (Table 2.5). The coniferous forests of the Mediterranean, Anatolian and Macaronesian regions comprise the “strict” Mediterranean forests (as described earlier), and Table 2.5 also includes thermophilous and broadleaved deciduous forests (which may include tree species that also occur in other parts of Europe).

Table 2.5. Mediterranean forest types based on the European forest types classification

8. Thermophilous deciduous forest	The deciduous forests in this category mainly occur in the supra-Mediterranean vegetation belt, the altitudinal belt of Mediterranean mountains corresponding to the mountainous level of middle European mountains. Thermophilous deciduous forests are limited to the north (or upslope) by temperature and to the south (or downslope) by drought. The mild climatic conditions of the supra-Mediterranean level determine the predominance of mixed deciduous and semi-deciduous forest of thermophilous species, mainly of *Quercus. Acer, Ostrya, Fraxinus* and *Carpinus* species are frequent as associated secondary trees. Anthropogenic exploitation has modified the natural mixed composition of thermophilous deciduous forests, leading in most cases to the elimination of natural species of low commercial interest or with poor resprouting capacity or, conversely, to the introduction of forest species that would not occur naturally (*e.g.* chestnut). Simplified forest structures shaped by traditional silvicultural systems predominate (coppice, coppice with standards, mixed coppice/high forest); chestnut groves are also of purely cultural origin, today largely replaced by coppice-woods or left unmanaged. High forest-like structures developing after the abandonment of forest cultivation are relatively frequent in the category.
9. Broadleaved evergreen forest	Forests in this category are related to the thermo- and meso-Mediterranean vegetation belts and to the warm-temperate humid zones of Macaronesia. These kinds of climate determine a forest physiognomy characterized by the dominance of broadleaved sclerophyllous or lauriphyllous evergreen trees. Water availability varies considerably between the Macaronesia and thermo- and meso-Mediterranean vegetation belts and is the main climatic factor limiting tree growth. In the Mediterranean, the structure of broadleaved evergreen forest has been profoundly shaped by traditional agroforestry (*dehesas*, *montados*) and coppice cultivation systems. Forest degradation is common, due to a complex historical interplay of harsh environmental conditions (drought, aridity and soils prone to erosion) and anthropogenic influences (fire, grazing and intensive forest exploitation).
10. Coniferous forests of the Mediterranean, Anatolian and Macaronesian regions	This category includes a large group of coniferous forests, mainly xerophytic forest communities, distributed throughout Europe from coastal regions to high mountain ranges. Forest physiognomy is mainly dominated by species of *Pinus, Abies* and juniper, which are variously distributed according to altitudinal vegetation belts. Dry conditions and, often, poor or poorly developed soils limit tree growth. Although some pine forests in this category are adapted to fire (*e.g. P. halepensis* and *P. canariensis*), repeated forest fire of anthropogenic origin seriously threatens these coniferous forests. From a structural viewpoint, even-aged forests characterize the category.
12. Floodplain forest	The riparian or alluvial hydrological regime (high water table subject to occasional flooding) determines the appearance of forests in this category, distributed along the main European river channels. Floodplain forest are species-rich and often multi-layered communities characterized by assemblages of species of *Alnus, Betula, Populus*, *Salix*, *Fraxinus* and *Ulmus*. In the Mediterranean and Macaronesian regions, local species are also found (*e.g. Fraxinus angustifolia*, *Nerium oleander*, *Platanus orientalis* and *Tamarix*). Forest composition and structure largely depend on the frequency of flooding. Anthropogenic activities like river damming and canalization and the drainage of riparian areas to provide agricultural land brought significant changes to the area of floodplain forest over the last century. The conservation and restoration of these riparian forests is the main focus of forest management today.

Source: European Environment Agency, 2006.

These forest types do not refer specifically to countries outside Europe, and data were provided through a voluntary process in preparation of a report on the state of Europe's forests (Ministerial Conference on the Protection of Forests in Europe, 2007). Therefore, Table 2.6 presents data for only a few Mediterranean countries (Bulgaria, Croatia, Cyprus, France, Italy, Slovenia and Spain); it shows the total area of forest in those countries, by European forest type, and also the estimated area of Mediterranean forest calculated by summing categories 8, 9, 10 and 12. Note that the selected categories may include non-Mediterranean forests.

Figure 2.11 shows an assessment of the Mediterranean forest area in the Mediterranean region, on the basis of the values presented for some European countries in Table 2.6 and assuming that the percentage of Mediterranean forest in Northern African countries is 100 percent.

Table 2.6. Extent of forest by European forest type for seven Mediterranean countries, 2010

Country	European forest types, by area (1 000 ha)																
	1 Boreal forest	2 Hemiboreal and nemoral coniferous and mixed broadleaved forest	3 Alpine forest	4 Acidophilous oak and oak-birch forest	5 Mesophytic deciduous forest	6 Beech forest	7 Mountainous beech forest	8 Thermophilous deciduous forest	9 Broadleaved evergreen forest	10 Coniferous forests of the Mediterranean, Anatolian and Macaronesian regions	11 Mire and swamp forest	12 Floodplain forest	13 Non-riverine alder, birch or aspen forest	14 Introduced tree species forest	Unclassified forest	Total	Estimate of the extent of Mediterranean forest (1 000 ha)	Estimated % of Mediterranean forests
Bulgaria	0	326	815	0	353	414	113	1690	0	9	0	0	0	207	0	3927	1699	40
Croatia	0	25	34	59	415	181	564	225	80	53	0	201	0	83	0	1920	559	20
Cyprus	0	0	0	0	0	0	0	1	0	171	0	0	0	1	0	173	172	100
France	0	1797	430	2228	3092	585	1913	2009	827	392	76	381	341	744	332	15147	3609	20
Italy	0	81	1240	0	161	63	1018	3553	913	393	0	113	131	341	1143	9149	4972	60
Slovenia	0	79	33	19	112	489	431	86	0	0	0	3	0	0	0	1252	89	10
Spain	0	400	490	146	103	89	264	1555	5565	5207	0	182	16	886	3269	18173	12509	70

Note: The area of Mediterranean forests was estimated by summing the categories “thermophilus deciduous forests”, “broadleaved evergreen forests”, “coniferous forests of Mediterranean, Anatolian and Macaronesian regions” and “floodplain forest”.
Source: Ministerial Conference on the Protection of Forests in Europe, 2007.

Figure 2.11. Extent of Mediterranean forest area in Mediterranean countries, 2010
Note: *For Bulgaria, Croatia, Cyprus, France, Italy, Slovenia and Spain, the value is estimated according to European forest types. For Northern African countries, it is assumed that Mediterranean forest comprises 100 percent of national forest area. For other European countries, the estimate is based on ecological zones and the total forest area.*
Source: *FAO.*

FAO Global Forest Resources Assessment remote sensing survey

An estimate of the extent of and changes in Mediterranean forests was obtained for the period 1990–2005 based on the global remote sensing survey described in FAO and JRC (2012). That survey used a systematic sampling grid design that involved sites located at the intersection of each degree of longitude and latitude worldwide, creating more than 13 000 sample sites approximately 100 km apart. Figure 2.12 shows the ecological zones of the Mediterranean countries. Based on a biogeographic–bioclimatic definition of Mediterranean forests, three main ecological zones were selected to define the distribution of Mediterranean forests: subtropical dry forest, subtropical steppe and subtropical mountain system. Figure 2.13 shows the distribution of the 10 km x 10 km Landsat imagery sample sites used to estimate forest cover in the selected ecological zones, and Figure 2.14 shows the distribution of Mediterranean forests derived by this process.

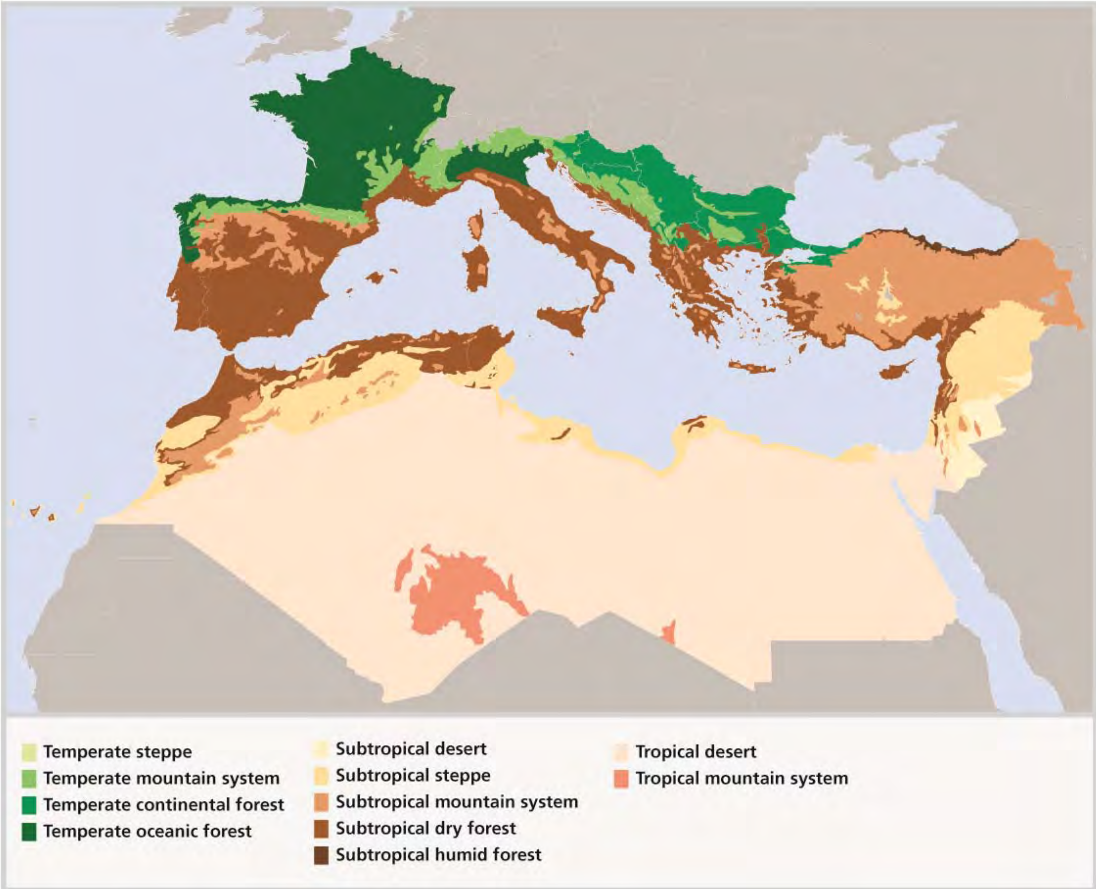


Figure 2.12. The FAO global ecological zones in the Mediterranean region used to identify the distribution of Mediterranean forests
Note: *The ecological zones assumed to contain Mediterranean forests are subtropical dry forest, subtropical steppe and subtropical mountain system.*
Source: *Derived from FAO and JRC, 2012 and Iremonger and Gerrand, 2011.*

Figure 2.13. Systematic distribution of Landsat imagery samples in the three identified ecological zones that constitute Mediterranean forests
Note: *The yellow dots represent Landsat imagery sample sites; the dark blue area represents the Mediterranean ecological zones of subtropical dry forest, subtropical steppe and subtropical mountain system.*
Source: *FAO.*

Figure 2.14. Distribution of Mediterranean forests
Note: Gradient of green = percent of forest cover; beige = OWLs (wooded areas with less than 10 percent canopy cover); brown = non-Mediterranean forests; grey = other land uses.
Source: FAO.

According to this method, there were about 25.5 million ha of Mediterranean forests in 2005. The data presented in Table 2.7 and Figure 2.15 indicate that there was no significant net change in the total area of Mediterranean forest between 1990 and 2005. However, the considerable gains and losses indicate that forest cover is dynamic.

Using data from the same remote sensing survey, the total forest cover in the Mediterranean countries (*i.e.* Mediterranean forests plus all other forests in Mediterranean countries) was estimated at 80 million hectares (± 10 million ha), with no significant change between 1990 and 2005.

Table 2.7. Mediterranean forest area and changes, 1990, 2000 and 2005

	Year	Mean	Lower limit	Upper limit
Area (1 000 ha)	1990	26 041	19 284	32 797
	2000	25 850	19 256	32 445
	2005	25 529	18 985	32 074
Net change (1 000 ha/yr)	1990–2000	-19	-87	49
	2000–2005	-64	-161	33
Gain (1 000 ha/yr)	1990–2000	114	65	163
	2000–2005	115	32	198
Loss (1 000 ha/yr)	1990–2000	-133	-195	-71
	2000–2005	-179	-264	-94

Note: Lower and upper limits represent the 95 percent confidence interval.
Source: FAO.

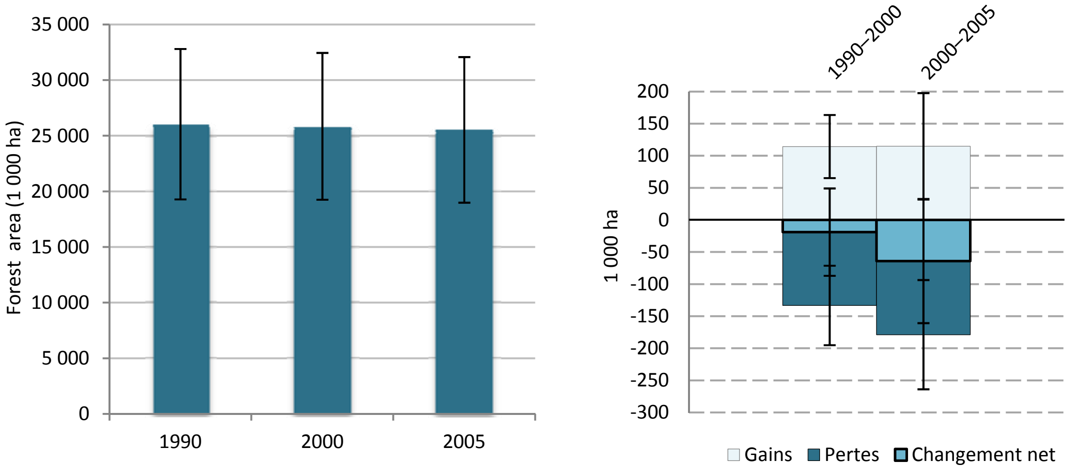


Figure 2.15. Mediterranean forest area, 1990, 2000 and 2005 (left), and average annual change in Mediterranean forest area, 1990–2000 and 2000–2005 (right)
Source: FAO.

Biodiversity in Mediterranean forests

The unusual geographical and topographical variability (*e.g.* ragged coasts and many mountain ranges) and a pronounced climatic bi-seasonality have strongly influenced species richness and distribution in the Mediterranean region, which is a biodiversity hotspot with high endemism (Myers *et al.*, 2000; Médail and Quézel, 1997; Figure 2.16).

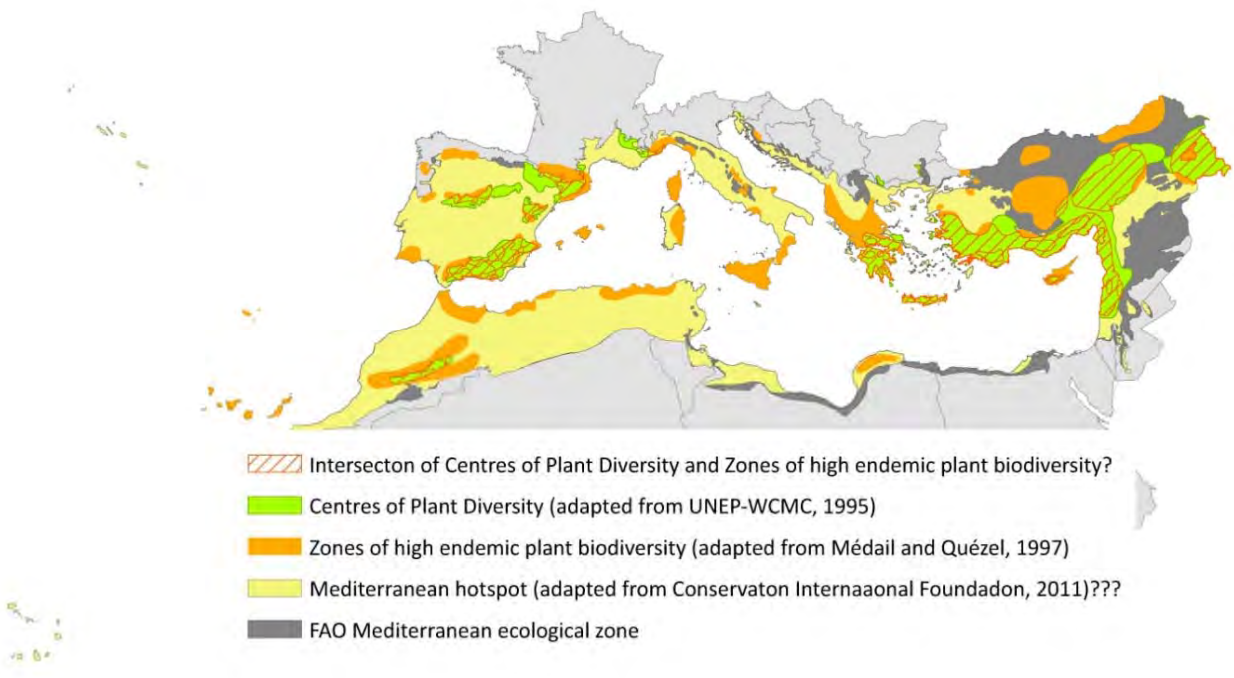


Figure 2.16. Mediterranean hotspots and centers of plant diversity
Sources: Médail and Quézel, 1997; Centres of Plant Diversity – version 1.0 of the global polygon and point dataset compiled by the United Nations Environment Programme–World Conservation Monitoring Centre, 1995, based on Davis, Heywooh and Hamilton, 2011.

Twenty-five percent of the approximately 200 terrestrial animals found in the region are endemic to it, and there are also 350 species of bird. Vertebrate diversity is strongly influenced by climatic changes that occurred during the Pleistocene and in recent decades, and by human pressures.

There are more than 25 000 plant species in the Mediterranean region, compared with about 6 000 in central and northern Europe (Scarascia-Mugnozza *et al.*, 2000). Mediterranean forests have nearly twice the number of woody species than central and northern European forests (247 vs. 135); 158 of the species in Mediterranean forests are exclusive to those forests or largely preferential, compared with 46 in central and northern European forests. In the Mediterranean forests, for example, there are seven endemic *Acer* species (*A. pseudolatanus, A. platanoides, A. opalus, A. campestre, A. monspessolanum, A. lobelii* and *A. peronai*), eight fir species *(Abies pinsapo, A. marocana* incl. *A. tazaotana, A. numidica, A. cephalonica* incl. *A. borisii-regis, A. cilicica, A. equi-trojani, A. nebrodensis* and *A. alba)* and nine pine species (*P. nigra and its varieties, P. cembra, P. mugo, P. sillvestris, P. pinea, P. halepensis, P. brutia, P. pinaster* and *P. heldreichii*); *Cupressus* and *Cedrus* are also present in the region. There is a similar difference in genera: 34 genera of woody species occur exclusively in Mediterranean forests, compared with seven that occur exclusively in central and northern European forests.

Most European species are found in the Mediterranean region, and in many cases subspecies and varieties can be distinguished. *Cupuliferae*, which includes beech, oaks and chestnut and is well-represented in the region, is of high economic importance and has a wide range of uses. Chestnut *(Castanea sativa)* forests cover several million hectares in the Mediterranean countries and are a valuable source of food, fodder and wood. *Quercus* is another well-represented genus, with a great range of taxa (*e.g. Q. robur, Q. petraea, Q. pubescens, Q. frainetto, Q. vallonea, Q. cerris, Q. ilex, Q. coccifera* and *Q. suber*). A considerable number of associated woody species are found throughout the Mediterranean region, particularly within the *Acer, Cotoneaster, Prunus, Pyrus, Salix* and *Sorbus* genera. Notable deciduous species include *Q. afares* in northeastern Maghreb, *Q. euboica* in Euboea (Greece), *Q. vulcanica* in central Anatolia (Turkey) and *Arbutus pavarii* in Cyrenaica (Libya). *Olaeceae* (*Olea eropaea*, *Fraxinus excelsior*, *F. ornus* and *F. angustifolia*) also plays a significant role in the Mediterranean economy. Forests of *Liquidambar orientalis,* a preglacial relict, occur in small areas of Turkey (Alan and Kaya, 2003).

Quézel (1995) reported on endemic forest elements of African vegetation, of which *Argania spinosa* and *Acacia gummifera* have significant economic value. Of the few other endemic species, *Phoenix theophrastii* is present in Crete and southwestern Anatolia (Yaltirik and Boydak, 1991) and *Chamaerops humilis* is found at several sites in the central Mediterranean.

The Mediterranean islands host a high number of endemic woody species, especially in small relict populations. For example, Sicily hosts *Abies nebrodensis* (Morandini *et al.*, 1994), *Celtis aetnensis* and *Zelkova sicula* (Di Pasquale *et al.*, 1992). In Crete, *Zelkova abelicea* grows in suitable conditions in mountain areas. In Cyprus, *Cedrus brevifolia* grows at the meso-Mediterranean level (900–1 200 m) and *Quercus alnifolia* populations can be observed at 1 200–1 900 m.

The Mediterranean region was a refugial area for European, North African and Near East flora and fauna during the Quaternary (Hewitt, 1999; Petit *et al.*, 2003; Cheddadi *et al.*, 2009; Médail and Diadema, 2009) and, as a consequence, 50 percent of the Mediterranean flora is endemic to the region. Species requiring Mediterranean bioclimatic conditions and currently found in the Mediterranean region evolved over a long period and were already present during the last glacial stage of the Pleistocene.

Mediterranean forests contain about 250 arborescent species, among which 150 species are endemic or are mainly found in the Mediterranean region; in addition, 15 genera are specific to forests in the region (Quézel *et al.*, 1999). Fady (2005) showed that conifer genetic diversity decreases along an east–west gradient, probably due to past climatic gradients during the Last Glacial Maximum (21 000 years ago).

Nevertheless, the high biodiversity in the Mediterranean region is threatened by habitat loss (Myers *et al.*, 2000). According to the EU's 1992 Habitats Directive, which implements a network of protected areas for the conservation of biodiversity within the EU (*i.e.* Natura 2000), 386 endangered species and 142 habitats in the Mediterranean are in need of protection. Anthropogenic pressures, habitat loss, landscape degradation, fire, soil erosion and climate change are some the drivers of forest biodiversity loss in the region. Implementing concrete measures for biodiversity and forest genetic conservation is a difficult challenge which requires an integrated approach that encompasses the environmental, economic and social dimensions.

2.2 Biotic and abiotic disturbances in Mediterranean forests

Forest fire

Fire is a cause of forest degradation in the Mediterranean region. Over millennia, human activities in Mediterranean landscapes have modified natural forest fire dynamics and the capacity of vegetation to respond to disturbance (*i.e.* resilience). Prevailing climatic conditions also play a profound role: the moisture content of litter is affected by a prolonged hot and dry season (from June to end October), with average daytime temperatures above 30° C, little rain, and wind characterized by high speeds and strong desiccating power. Climate change may be leading to greater weather extremes (*e.g.* droughts and heat waves), exacerbating the threat posed by fire (FAO, 2007).

In the Mediterranean region, long time-series of forest fire data are available mainly for France (see Box 2.1), Greece, Italy, Portugal and Spain, whereas the situation in other Mediterranean countries is often analyzed separately because of disparities in the data. The European Forest Fire Information System (EFFIS), established by the Joint Research Centre and the Directorate General for Environment of the European Commission to support fire management in Europe, is the main source of harmonized data on forest fire in Europe on the basis of information on fire provided voluntarily by countries. Since 2010, EFFIS has also included northern African countries in the mapping of burnt areas and the assessment of fire danger. This is a first step towards the expansion of EFFIS to non-European countries in the Mediterranean region in the context of collaboration between the European Commission and the FAO Committee on Mediterranean Forestry Questions-*Silva Mediterranea*. Because of their recent inclusion in EFFIS, the northern African data presented in this report were provided mainly by local authorities. Other data were collected from national reports, such as those compiled for FAO (2010) and FAO (2006), and other sources cited in Figure 2.17.

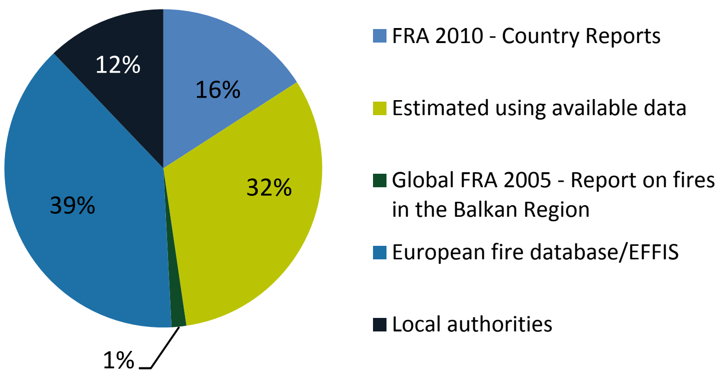


Figure 2.17. Sources of data on fire for the period 2000–2010

Considering the short time-series of data available for some countries, the period analyzed here is 2000–2010, with particular attention on 2006–2010. Figure 2.18 shows the availability of data for 2000–2010.

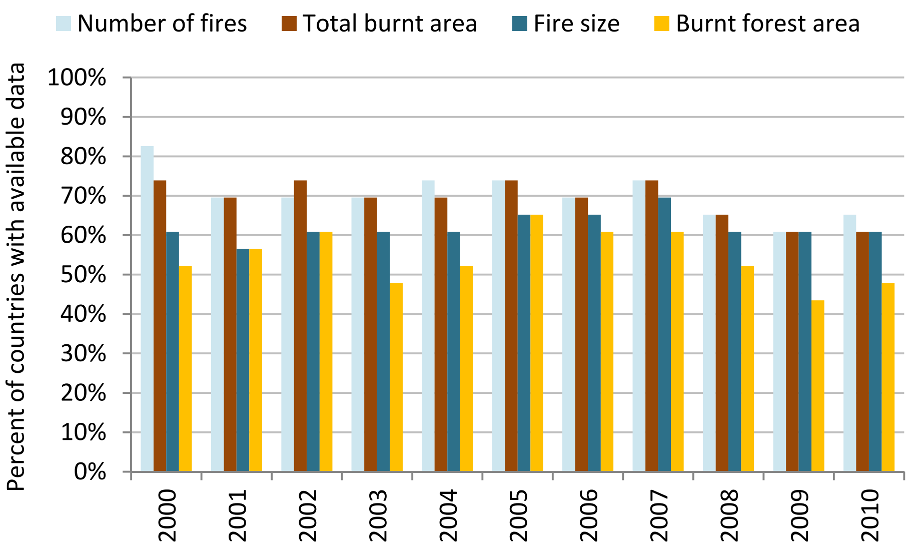


Figure 2.18. Availability of data on various fire parameters, 2000–2010

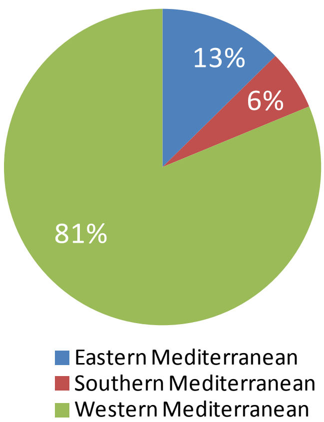
To analyze the spatial distribution of fire in the Mediterranean, countries were categorized as either western Mediterranean, eastern Mediterranean or southern Mediterranean (Figure

2.19). The fire situation and level of risk are significantly different in these three parts of the Mediterranean.

Figure 2.19. The eastern, western and southern Mediterranean subregions

Number of fires in the Mediterranean, 2006–2010

Five countries accounted for more than 85 percent of the total number of fires in the period 2006–2010. More than 269 000 fires were reported in the Mediterranean region in 2006–2010[3], an average of just under 54 000 per year. Of the total number of fires, 81 percent occurred in western Mediterranean countries (Figure 2.20). Figure 2.21 shows the incidence of fire in those countries for 2000–2010). Portugal reported the highest number of fires (Figure 2.22) (EU Commission, 2011), and fire density was highest in Portugal and Spain (Figure 2.23).



3 For the period 2006–2010, data were missing or incomplete for Albania, Croatia, Israel, Jordan, Serbia, the Syrian Arab Republic and The former Yugoslav Republic of Macedonia. As a consequence, the total amount is underestimated.

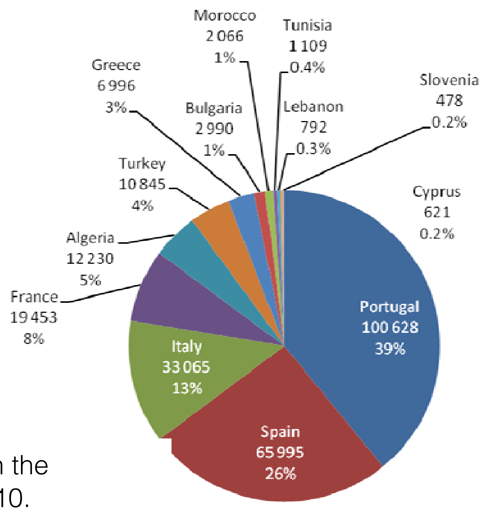


Figure 2.20. Location of fires in the Mediterranean region, 2006–2010. Sources: FAO, 2006a and b; FAO, 2010b; EFFIS and European Forest Fire Database; local authorities.

Figure 2.21. Total number of fires in Mediterranean countries with complete data series, 2006–2010
Sources: FAO, 2006a and b; FAO, 2010b; EFFIS Network and European Forest Fire Database; local authorities

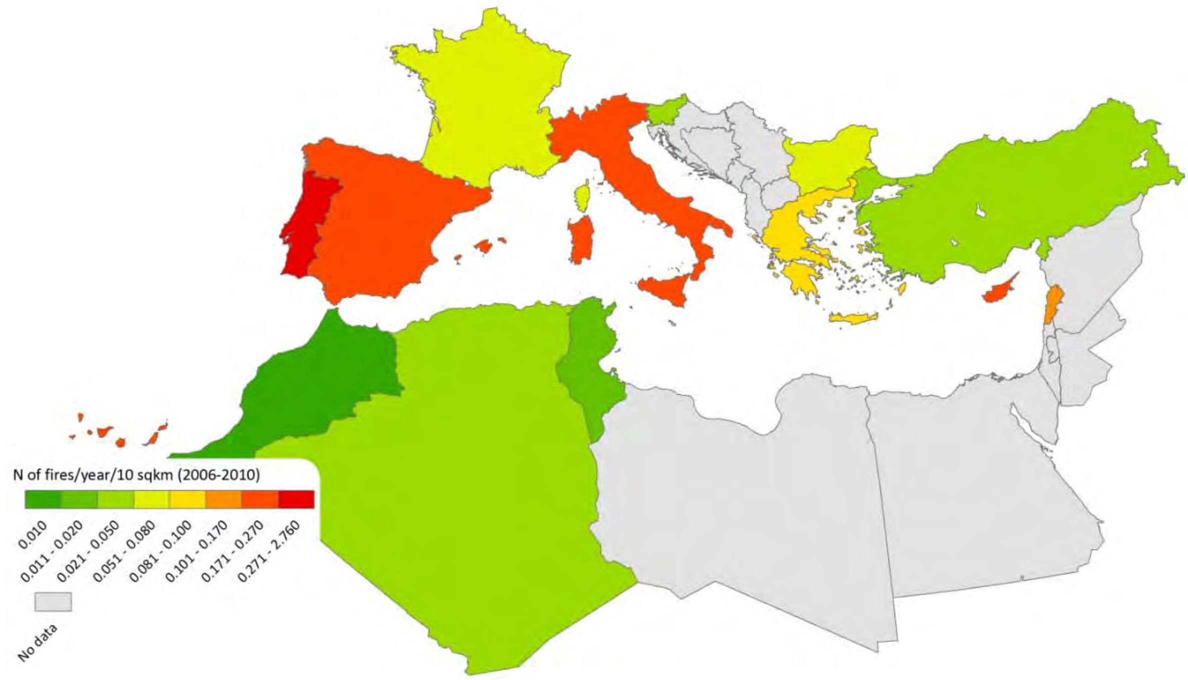


Figure 2.22: Fire density, Mediterranean region, 2006–2010
Note: Countries shown in grey did not provide complete data on fire occurrence for the period. Fire density = total number of fires per year per 10 km^2 of wildland area, where wildland area is the area potentially affected by wildfire (*i.e.* land area, excluding urban areas).
Sources: FAO, 2006b; FAO, 2010b; EFFIS and European Forest Fire Database; local authorities.

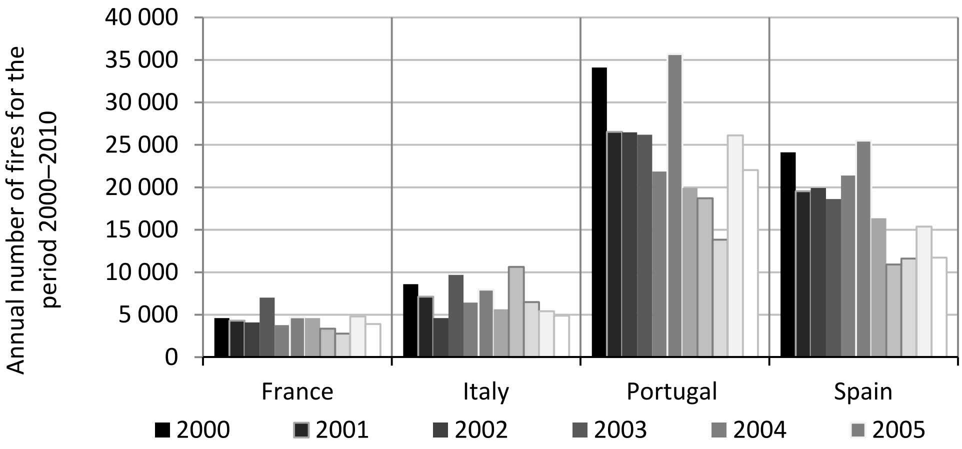


Figure 2.23. Number of fires in western Mediterranean countries, 2000–2010
Source: FAO, 2006a and b; FAO, 2010b; EFFIS Network and European Forest Fire Database; local authorities.

Burnt area in the Mediterranean, 2006–2010

Four countries accounted for almost 80 percent of the total burnt area in the period 2006–2010. In total, more than 2 million ha were burnt in the Mediterranean in that period, an average of more than 400 000 ha per year. Figures 2.24 and 2.25 show that 78 percent of the total burnt area in 2006–2010 was in only four countries (Greece, Italy, Portugal and Spain), but there were strong annual variations (Figure 2.26). Two countries (Portugal and Spain) accounted for more than 50 percent of the total burnt area.

Nine countries, collectively representing 67 percent of the total forest area in the Mediterranean region, provided information on the area of forest burnt in 2006–2010. In those countries, the total area of burnt forest in the period was 730 907 ha.

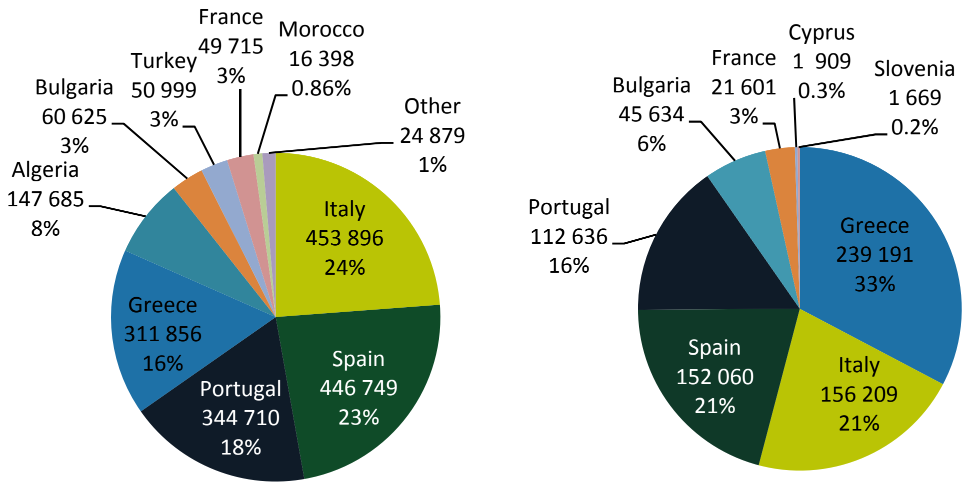


Figure 2.24. Burnt area in Mediterranean countries that provided complete data series, 2006–2010 (left), and burnt forest area in Mediterranean countries that provided complete data series, 2006–2010 (right)
Note: Other = Cyprus, Lebanon, Slovenia and Tunisia.
Sources: FAO, 2006a and b; FAO, 2010b; EFFIS and European Forest Fire Database; local authorities.

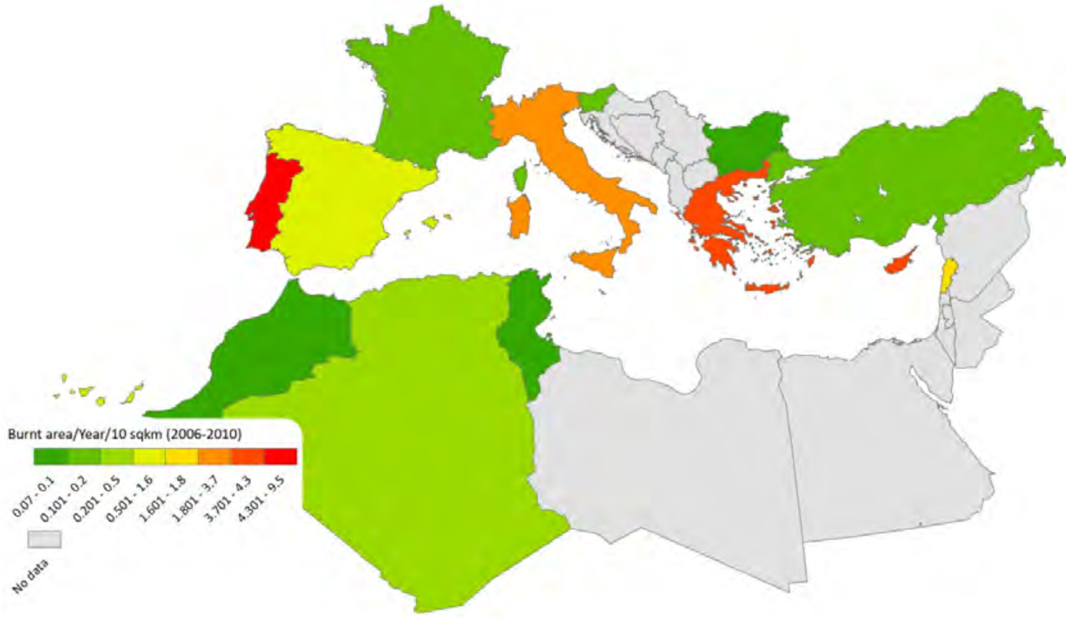


Figure 2.25. Burnt area (ha) per year, Mediterranean region, 2006–2010
Note: Countries shown in grey did not provide complete data on burnt area for the period. Burnt area = hectares burnt per year per 1 000 ha of wildland area, where wildland area is the area potentially affected by wildfire (*i.e.* land area, excluding urban areas).
Sources: FAO, 2006a and b; FAO, 2010b; EFFIS and European Forest Fire Database; local authorities.

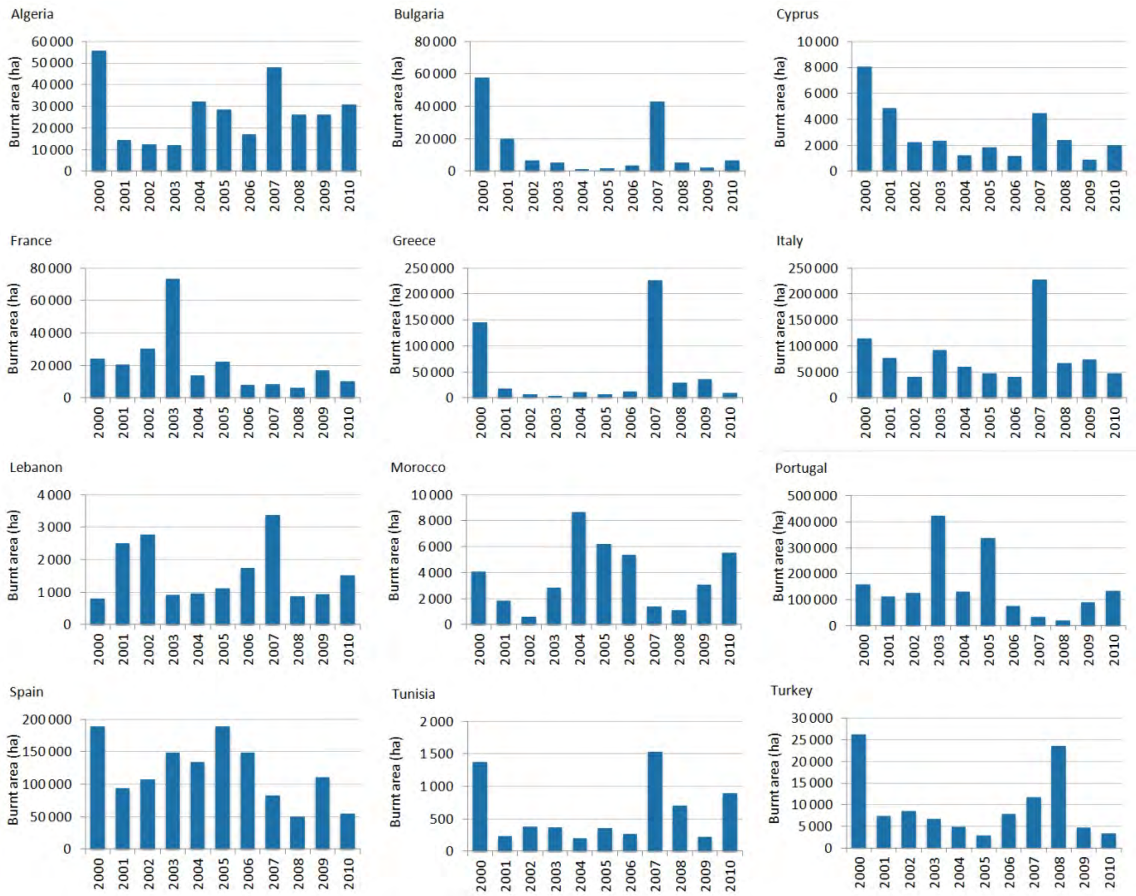


Figure 2.26. Annual burnt area, 13 Mediterranean countries with complete data series, 2000–2010
Sources: FAO, 2006; FAO, 2010b; EFFIS and European Forest Fire Database; local authorities.

Wildfires in the Mediterranean region in the last decade

The situation in 2006–2010 is comparable with the period 2003–2007 (Figure 2.27), when the total number of wildfires was 342 905 (about 70 000 per year) and the total burnt area was over 3 million ha (about 600 000 ha per year). In both periods, more than 50 percent of the number of wildfires and the area burnt were in two countries, Portugal and Spain. Overall, more than 5 million ha were burnt in the Mediterranean region in 2003–10, not all of it forest, and there were more than 600 000 wildfires.

The temporal and spatial distribution of wildfire in the Mediterranean region is influenced by several factors and there is considerable year-to-year variation. Nevertheless, the consequences of wildfire are severe in Mediterranean forest ecosystems, increasing pressure on forests and affecting human well-being (see Box 2.1). Nevertheless the use of fire at certain times of the year can also be considered as a tool to prevent forest fires during the summer period (see Box 2.2).

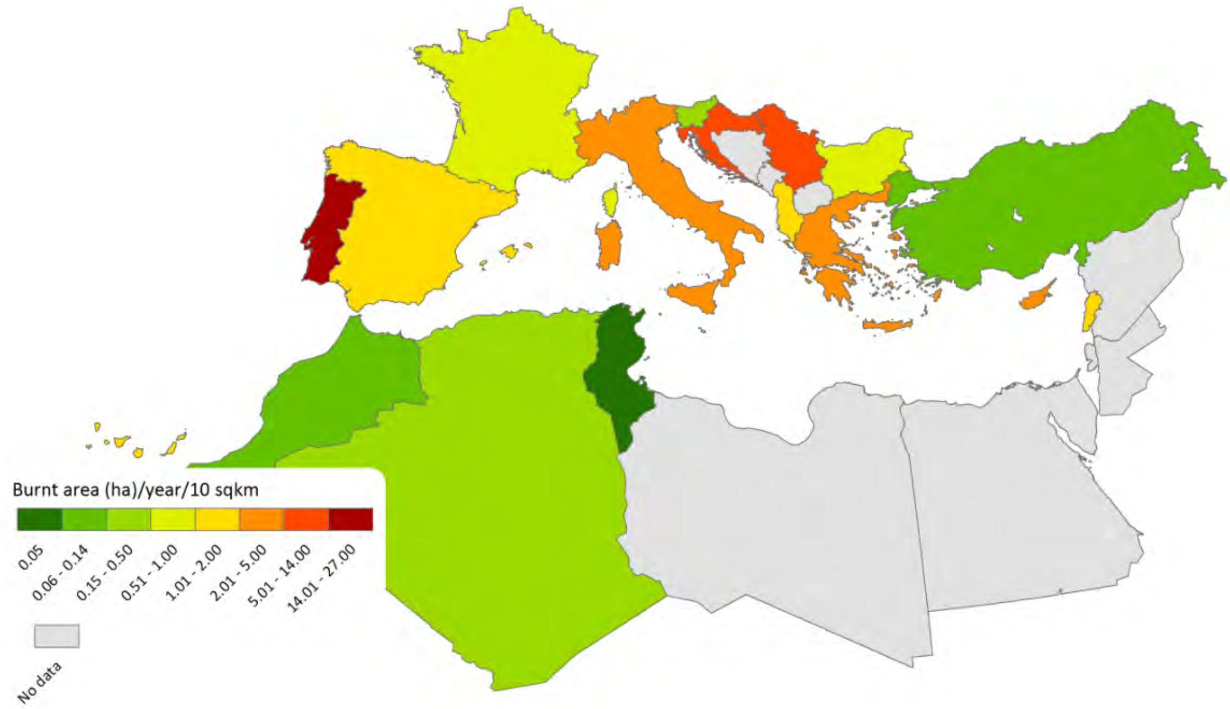


Figure 2.27. Burnt area per year, Mediterranean region, 2003–2007
Note: Countries shown in grey did not provide complete data on burnt area for the period. Burnt area = hectares burnt per year per 1 000 ha of wildland area, where wildland area is the area potentially affected by wildfire (*i.e.* land area, excluding urban areas).
Sources: FAO, 2006a and b; FAO, 2010b; EFFIS and European Forest Fire Database; local authorities.

Box 2.1 Wildfires in the French Mediterrean region

Table 2.8 shows that, in the period 2000–10, wildfire in the French Mediterranean accounted for about 49 percent of the total number of wildfires and 69 percent of the total burnt area in France. It also shows that, unless exceptional year (2002), about 70-80 percent of the burnt area in France is in the Mediterranean region. Figure 2.28 shows the high number of small wildfires.

Table 2.8. Percentage of wildfires and burnt area in the French Mediterranean region compared with the total number of wildfires and burnt area in France

Year	No. of fires (% of total number)	Burnt area (% of total area burnt)
2010	35	60
2005	40	78
2009	41	65
2002	41	21
2008	48	62
2006	49	70
2003	50	84
2000	53	78
2004	54	77
2001	65	87
2007	69	76

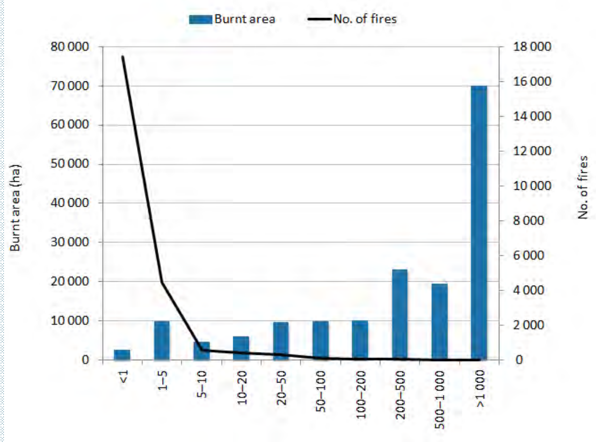


Figure 2.28. Total number of fires and burnt area, French Mediterranean, 2000–2010

Source: Prométhée (French database on forest fire in the Mediterranean region).

An important source of data for estimating the area burnt by wildfire in the Mediterranean region is Moderate Resolution Imaging Spectroradiometer (MODIS) satellite imagery.[4] MODIS data enable the mapping of wildfires affecting more than 40 ha. Although this is only a fraction of the total number of wildfires, it represents about 75 percent of the total area burnt each year in the southern EU (EU Commission, 2011). Figure 2.29 and Table 2.9 show the area burnt by wildfires greater than 40 ha in size in 2008, 2009 and 2010, for a total of 881 178 ha over the period.

[4] Most Northern African countries have become involved in satellite-based fire monitoring relatively recently; for these countries, data are available only from 2008.

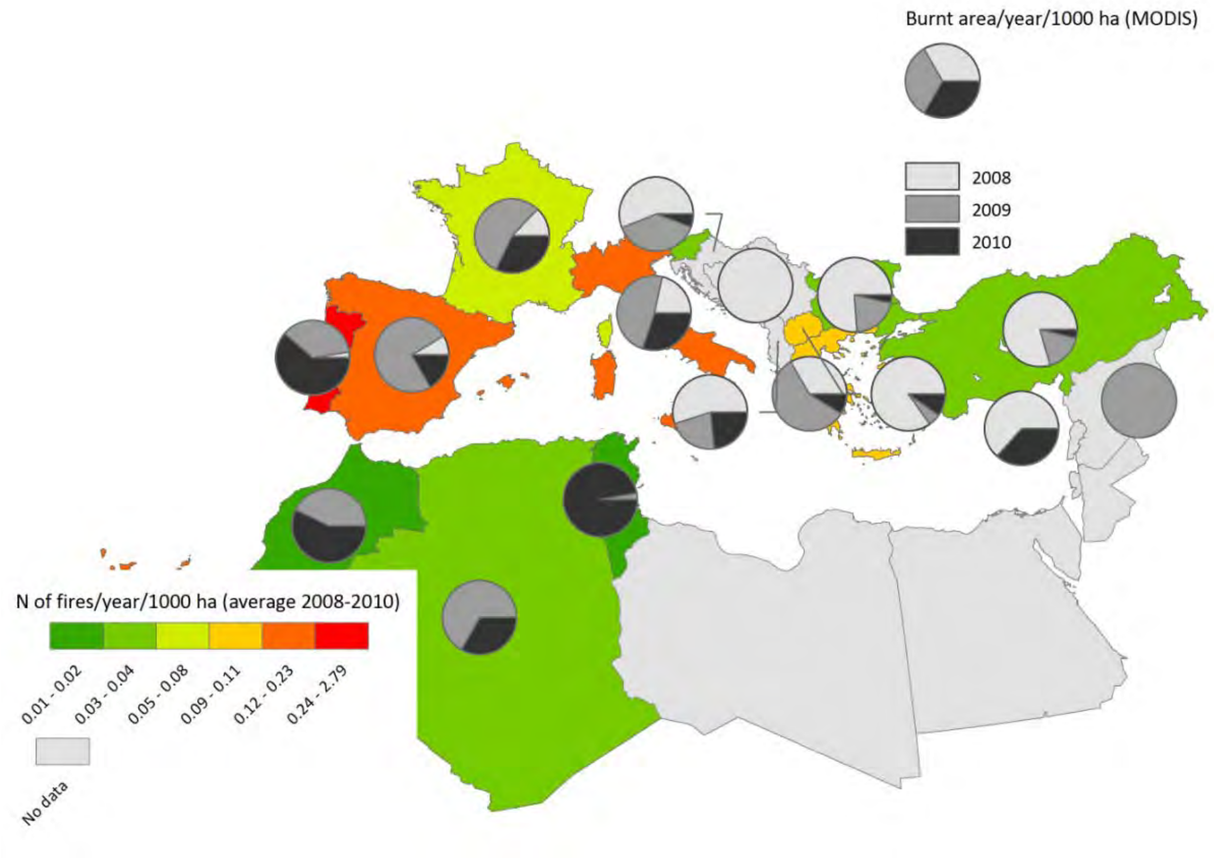


Figure 2.29. Number of wildfires per year, Mediterranean countries, 2008–10
Sources: FAO, 2010b and EFFIS, 2010.

Table 2.9. Area burnt by wildfire greater than 40 ha in size, Mediterranean countries, 2008–2010

	Burnt area (ha)									
Year	Albania	Algeria	Bosnia	Bulgaria	Croatia	Cyprus	France	FYROM	Greece	Israel
2008	19 254	n.s.	6 962	5 731	3 217	1 947	1 695	14 463	24 573	n.s.
2009	7 607	141 925	181	1 564	2 208	n.s.	7 972	901	42 760	46
2010	8 155	70 747	3 350	28	330	1 122	4 677	1 692	6 496	3 013
Year	Italy	Montenegro	Morocco	Portugal	Serbia	Slovenia	Spain	Syrian Arab Republic	Tunisia	Turkey
2008	24 450	5 772	n.s.	5352	629	n.s.	10 072	n.s.	n.s.	27 848
2009	54 943	103	2 112	75 265	n.s.	n.s.	88 886	5 276	129	5 797
2010	34 379	2 088	2 826	127 891	n.s.	n.s.	19 915	n.s.	3 551	1 278

Note: FYROM = The former Yugoslav Republic of Macedonia; ns = not significant.
Source: EFFIS, 2010.

Average fire size in the Mediterranean region, 2000–2010

Figure 2.30 shows the average fire size in the Mediterranean region in the period 2000–2010. Fire size was significantly greater in Algeria, Bulgaria, Cyprus, Greece and Italy compared with other Mediterranean countries. The disastrous fire seasons in 2003 and 2007 are particularly evident. Although Portugal had the highest number of wildfires and largest burnt area in the Mediterranean, the average fire size was relatively low, which is possibly related to effective intervention measures.

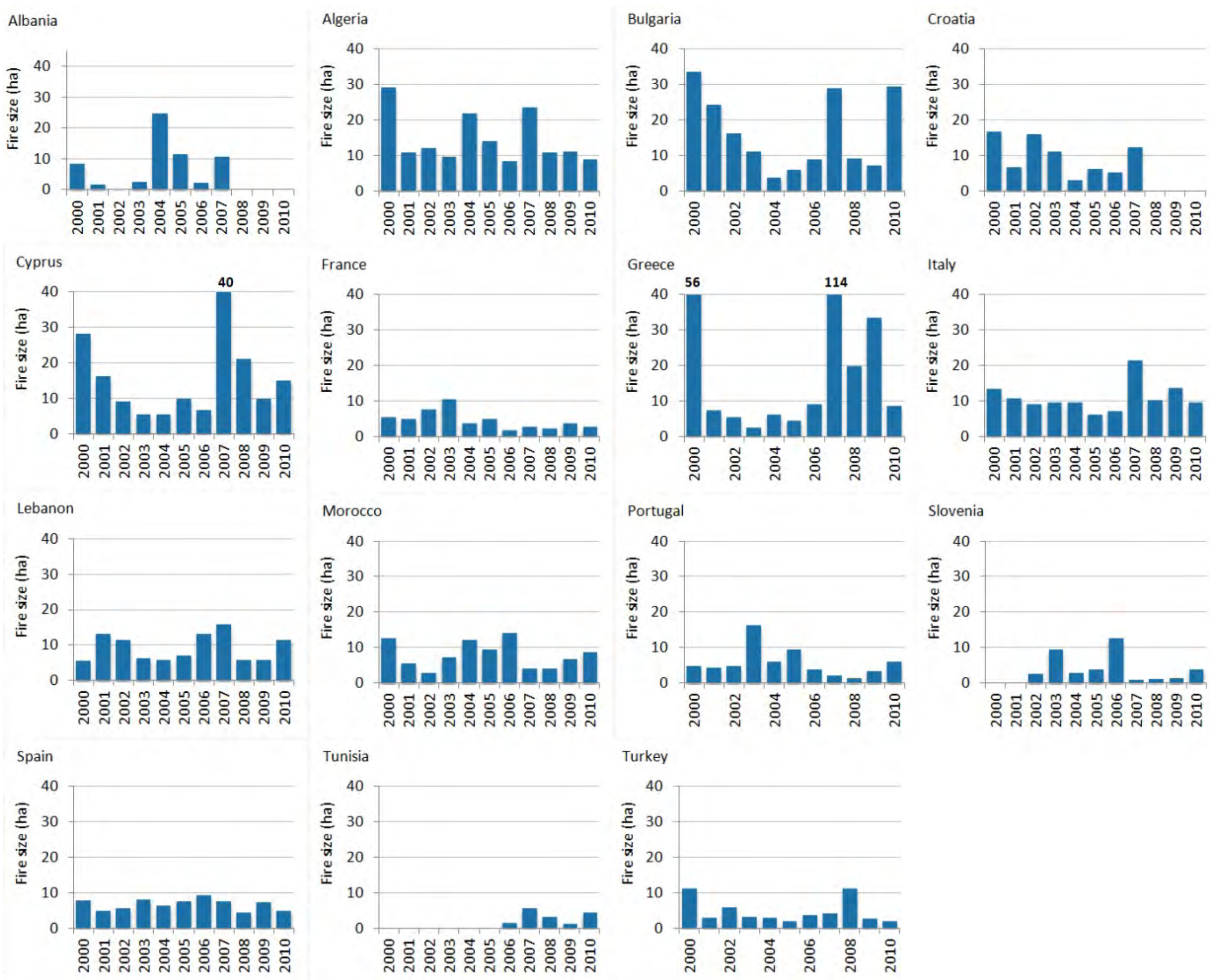


Figure 2.30: Fire size in Mediterranean countries, 2000–10
Sources: FAO, 2006a and b; FAO, 2010b; EFFIS and European Forest Fire Database; local authorities.

Box 2.2 The use of fire as a tool for preventing wildfires

In Mediterranean rural areas, fire has often been used as a land management tool, mainly for the maintenance of grasslands and the elimination of undesirable vegetation. The use of backfires to help control wildfires is part of the traditional knowledge held by local Mediterranean people. However, the increased risk of fire propagation due to the abandonment of rural areas and the consequent increase in fuel loads, together with the proximity of urban areas to forests, requires the review, regulation and support of the use of fire as a traditional tool.

Fire is a natural element of many Mediterranean ecosystems. Some Mediterranean forest types are adapted to frequent and low-intensity wildfires caused naturally by lightning. Spontaneous wildfires control understorey vegetation growth, limiting fuel loads and preventing severe wildfires that can burn all vegetation strata and have a huge impact on ecosystem function and resilience. In these forest types, understorey grazing, for example, would emulate the role of fire disturbance on vegetation removal.

In many regions of the world, greater knowledge of fire ecology is allowing the increased use of fire as a tool to prevent large wildfires. Prescribed burning offers a cost-effective means of limiting the build-up of fuel loads and, from an ecological point of view, can improve forest health and vitality. Prescribed burning can also be a useful tool for the recovery and conservation of certain habitats (*e.g.* habitat recovery for bird nesting areas in Ebre Delta, Catalonia).

Nevertheless, fire should be used only under specific technical, social, legal and ecological prescriptions. A precise knowledge of fire behaviour and the fire ecology of Mediterranean species is needed, taking into account the social acceptance of its use, and human health and safety.

With appropriate training and information, it will be possible to integrate more fully

Causes of forest fire

The limited available information suggests that the Mediterranean region is characterized by a heavy prevalence of human-induced wildfire. Figure 2.31 shows the cause of fire in five Mediterranean countries in 2010; "unknown" accounts for 51 percent of the total (ranging from 88 percent in Algeria to 14 percent in Bulgaria and 12 percent in Turkey). This confirms the need highlighted by the European Commission (2011) to improve knowledge and reporting on wildfire causes and for more post-fire investigation.

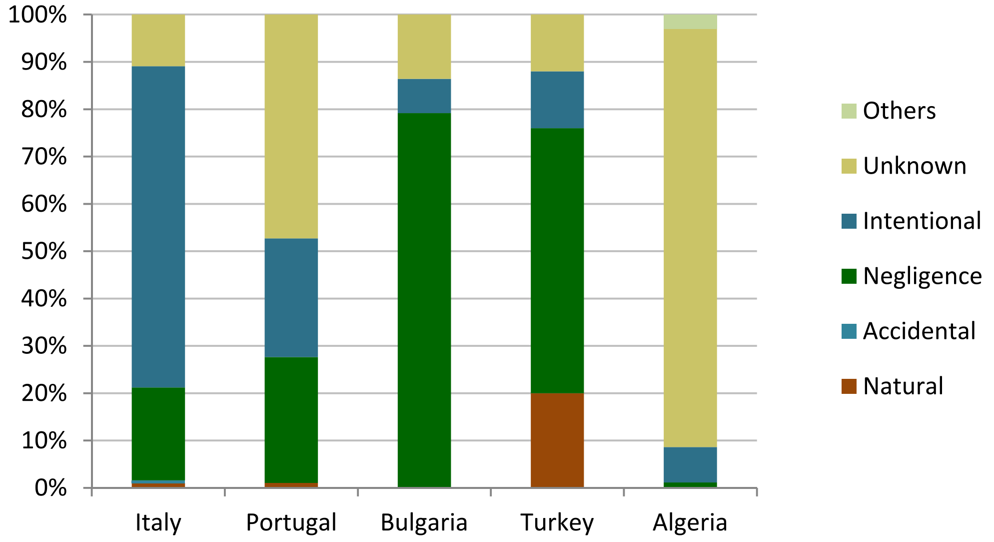


Figure 2.31. Fire causes in five countries in the Mediterranean region, 2010
Source: European Commission, 2011.

Example of wildfire causes. The Italian State Forest Service has developed a method for the investigation of fire causes, taking into account supposed and possible causes but also evidence obtained at fire scenes or derived from analyses and investigations. Once the cause of the fire is known, an investigation goes more deeply into the reasons (in the case of unintentional wildfires) and motivations (in the case of intentional wildfires). Figures 2.31 and 2.32 show that 68 percent of wildfires in Italy in 2010 were intentional.

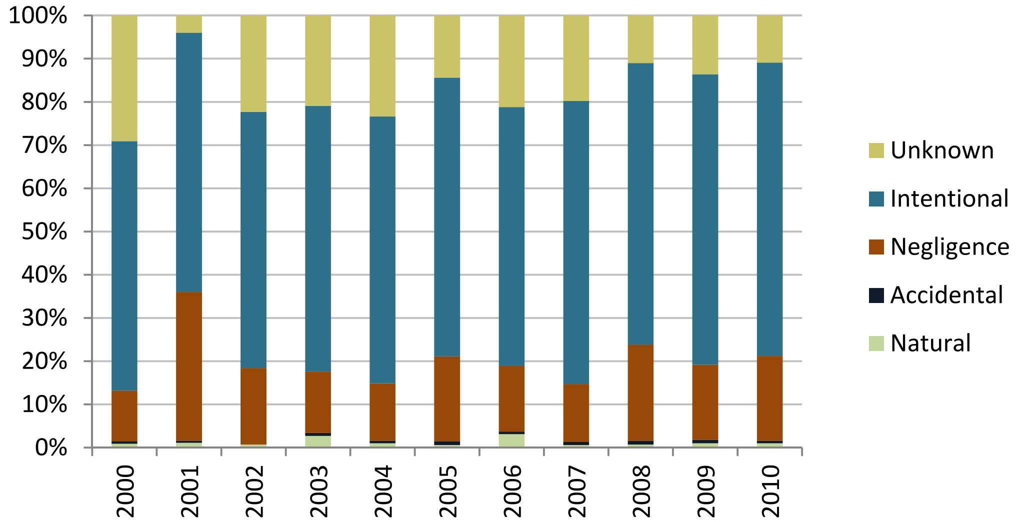


Figure 2.32. Fire causes in Italy, 2000–2010
Source: Italian State Forest Service, 2011

Thank to the provisions of the framework law on forest fires (No. 353/2000), a specialized task force for the investigation of the causes of forest fire (*Nucleo Investigativo Antincendi Boschivi*) was established within the Italian State Forest Service. A database on the area burnt by wildfire has also been established at the municipal level in order to record and geo-reference all forest fires that occur nationwide. This is increasingly being used to investigate the causes and development patterns of forest fires.

New European classification for forest fire causes adopted in 2011. The Italian method for the investigation of wildfire causes has contributed to the development of a new common classification scheme in the context of a European project lead by Cemagref (France) and EFFIS (Figure 2.33). This project aims to harmonize data across countries and facilitate the identification of the main drivers of fire ignition. The project should make it possible to improve reporting on forest fire causes in subsequent reports on the state of Mediterranean forests and in annual reports on forest fire in Europe published by EFFIS.

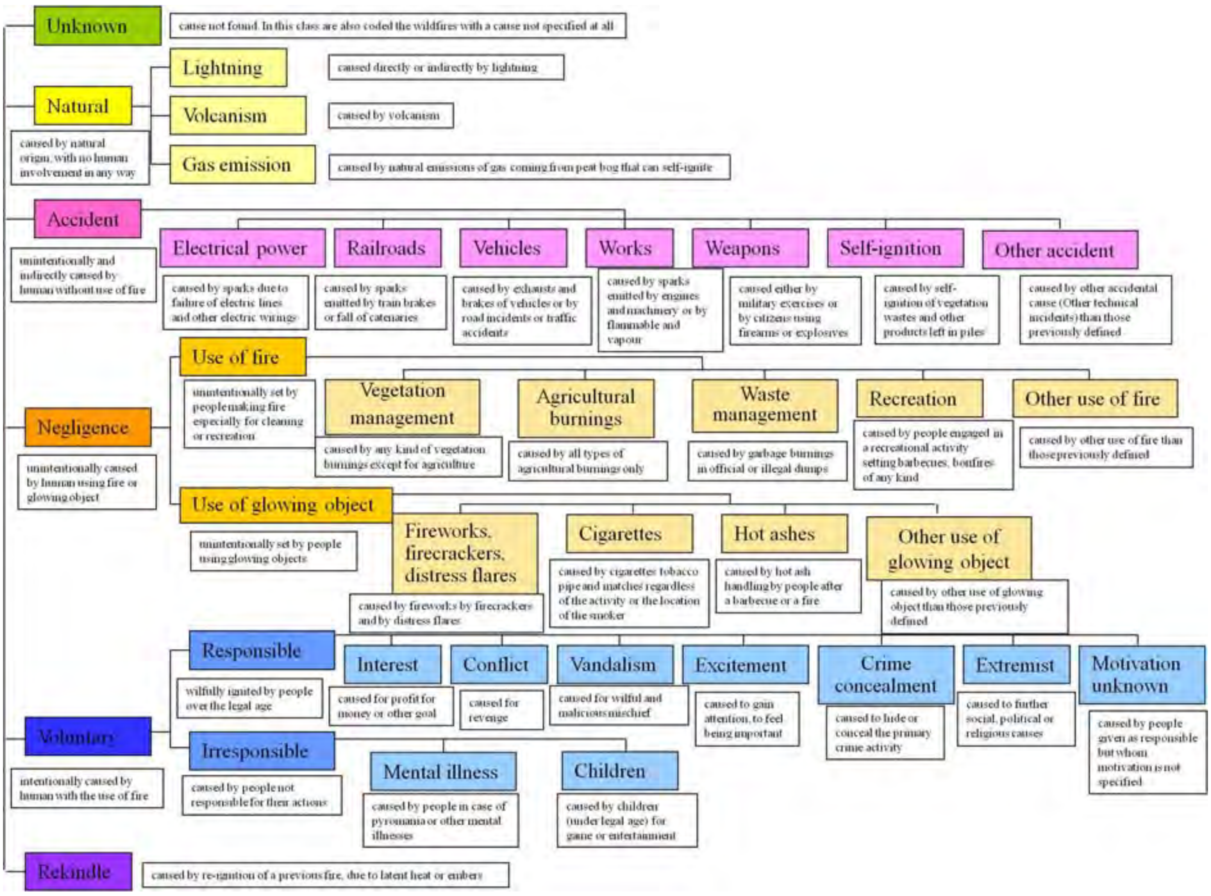


Figure 2.33. New fire causes classification scheme for Europe
Source: EC-JRC, 2012.

Insect pests, diseases and other disturbances

The Mediterranean forests share many common features, including climate, soils and forest composition. As a result of these similarities, they also share many forest health problems, including those associated with insect pests, disease, other biotic factors (such as woody invasive species, wildlife browsing and grazing), and abiotic factors (such as air pollution and storms).

For the Global Forest Resources Assessment (FAO, 2010b), countries were asked to report on the area of forest adversely affected by such disturbances. Countries were asked to provide data averaged over five years for three reporting years – 1990 (an average for the period 1988–1992), 2000 (average for 1998–2002) and 2005 (average for 2003–2007) – to help reduce the effect of large fluctuations between years.

Most countries were unable to provide reliable quantitative information of forest health because they do not systematically monitor the requested variables. Of the 31 Mediterranean countries, only 12 reported data for all three reporting years (1990, 2000 and 2005), and one country only reported data for abiotic disturbances for all reporting periods. Nineteen countries in the region reported data for the 2005 reporting period, but only 11 of those reported data for all four disturbance types (even if zero) (Table 2.10 and Figure 2.34).

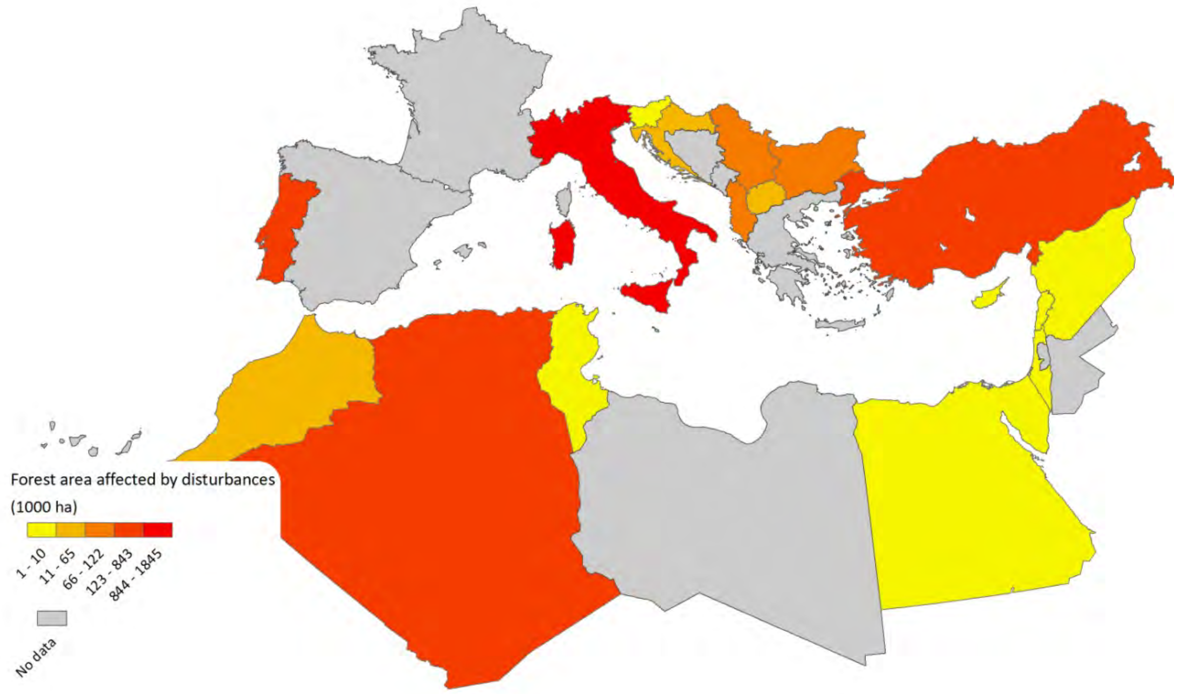


Figure 2.34. Total forest area affected by disturbances in Mediterranean countries, 2005
Source: FAO, 2010b.

Outbreaks of forest insect pests damage an estimated 35 million ha of the world's forests annually (FAO, 2010b). Of this global total, over 5 million ha were reported for the Mediterranean countries, which was about 14 percent of total reported damage worldwide and almost 6 percent of the total forest area of the region (Table 2.10).

Table 2.10. Average area of forest affected annually by insects, diseases, other biotic agents and abiotic disturbances in Mediterranean countries, 2005

	Area of forest affected (1 000 ha)			
Country	Insects	Disease	Other biotic	Abiotic
Albania	1	1	101	0
Algeria	217	..	..	..
Bulgaria	82	32	1	7
Croatia	27	10	8	19
Cyprus	6	0	4	0
Egypt	1	0	0	0
France	..	..	..	0
Israel	3	0	0	0
Italy	347	591	323	584
Lebanon	1	1	0	2
Morocco	33	..	16	..
Portugal	604	143	44	51
Serbia	118	..	..	..
Slovenia	1	0	0	1
Syrian Arab Republic	1	..	..	..
The former Yugoslav Republic of Macedonia	44	3	..	..
Tunisia	10	0	0	0
Turkey	172	12	..	11
TOTAL	1 668	794	498	675

Source: FAO, 2010b.

Insect pests and diseases

In listing the ten major outbreaks of insects and diseases that occurred since 1990, the Mediterranean countries reported a total of 89 insect pests and 34 diseases (FAO, 2010b). Tables 2.11 and 2.12 list the species that were reported by more than one country.

Insect pests indigenous to the region cause considerable damage and are among the most reported species (Table 2.11). Of the 27 insect pests reported by more than one country, four are introduced – *Leptocybe invasa*, *Ophelimus maskelli*, *Phoracantha recurva* and *P. semipunctata*. This may be more a reflection of the difficulties in identifying unknown pests than an accurate picture of the situation in the region.

Table 2.11. Average area of forest affected by abiotic and biotic disturbances in the Mediterranean region, 1990, 2000 and 2010

Country	Forest area (1 000 ha)			Area of forest affected (1 000 ha)									Percent of forest area affected by disturbances (1 000 ha)		
				Abiotic factors			Biotic factors			Total area affected by disturbances					
	1990	2000	2005	1990	2000	2005	1990	2000	2005	1990	2000	2005	1990	2000	2005
Albania	789	769	782	..	0	0	223	142	103	..	..	..	..	..	..
Algeria	1 667	1 579	1 536	..	..	..	241	130	217	241	130	217	14	8	14
Bosnia and Herzegovina	2 210	2 185	2 365	1	1	..	4	11	0	..	..	..	..	..	..
Bulgaria	3 327	3 375	3 651	9	23	7	156	222	115	165	245	122	5	7	3
Croatia	1 850	1 885	1 903	..	25	19	0	42	46	..	68	65	..	4	3
Cyprus	161	172	173	0	0	0	0	0	10	..	..	10	..	..	6
Egypt	44	59	67	..	0	0	0	1	1	..	1	1	..	1	2
France	1 4537	15 353	1 5714	13	229	0	0	0	0	..	..	..	..	..	..
Israel	132	153	155	1	1	0	11	2	3	11	4	3	8	2	2
Italy	7 590	8 369	8 759	..	588	584	0	943	1 261	..	1 531	1 845	..	18	21
Lebanon	131	131	137	..	..	2	0	1	2	..	1	4	..	0	3
Morocco	5 049	5 017	5 081	..	..	..	16	42	49	16	42	49	0	1	1
Portugal	3 327	3 420	3 437	37	21	51	480	275	791	516	296	843	16	9	25
Serbia	2 313	2 460	2 476	..	..	..	2	85	118	2	85	118	0	3	5
Slovenia	1 188	1 233	1 243	..	1	1	1	1	1	1	1	2	0	0	0
Spain	13 818	16 988	1 7293	..	..	..	421	406	0	..	..	..	..	..	..
Syrian Arab Republic	372	432	461	..	..	..	0	1	1	..	..	..	..	..	..
The former Yugoslav Republic of Macedonia	912	958	975	..	..	..	27	58	47	..	..	..	..	..	..
Tunisia	643	837	924	1	0	0	15	10	10	16	10	10	2	1	1
Turkey	9 680	10 146	10 740	..	34	11	250	333	184	250	367	195	3	4	2
Total	69 740	75 521	77 872	61	923	675	1 846	2 706	2 960	1 217	2 779	3 483	2	4	4

Source: FAO, 2010b.

Table 2.12. Insect pest species occurring in more than one country in the Mediterranean region, 2010

Pest	Countries	Order: Family	Main host
Chrysomela (=*Melasoma*) *populi*	Albania, Croatia	Coleoptera: Chrysomelidae	Poplar
Coleophora laricella	Croatia, The former Yugoslav Republic of Macedonia	Lepidoptera: Coleophoridae	Larch
Diprion pini	Bulgaria, Turkey	Hymenoptera: Diprionidae	Pine
Erannis defoliaria	Albania, The former Yugoslav Republic of Macedonia	Lepidoptera: Geometridae	Oak
Euproctis chrysorrhoea	Bulgaria, Croatia, The former Yugoslav Republic of Macedonia	Lepidoptera: Lymantriidae	Oak
Ips sexdentatus	The former Yugoslav Republic of Macedonia, Turkey	Coleoptera: Scolytidae	Pine
Ips typographus	Croatia, France, Serbia, Turkey	Coleoptera: Scolytidae	Spruce
Leptocybe invasa	Algeria, France, Greece, Israel, Italy, Jordan, Lebanon, Morocco, Portugal, Spain, Syrian Arab Republic, Tunisia, Turkey	Hymenoptera: Eulophidae	Eucalypt
Lymantria dispar	Algeria, Bulgaria, Croatia, Israel, Lebanon, Morocco, Serbia, The former Yugoslav Republic of Macedonia, Tunisia, Turkey	Lepidoptera: Lymantriidae	Oak
Neodiprion sertifer	The former Yugoslav Republic of Macedonia, Turkey	Hymenoptera: Diprionidae	Pine
Ophelimus maskelli	France, Greece, Israel, Italy, Portugal, Spain, Tunisia, Turkey	Hymenoptera: Eulophidae	Eucalypt
Orthotomicus erosus	Israel, Morocco, Tunisia, Turkey	Coleoptera: Scolytidae	Pine
Phloeosinus aubei	Albania, Tunisia	Coleoptera: Curculionidae	Cypress
Phoracantha recurva	Greece (one record), Morocco, Spain, Tunisia	Coleoptera: Cerambycidae	Eucalypt
Phoracantha semipunctata	Algeria, Cyprus, Egypt, France, Israel, Italy, Lebanon, Libya, Morocco, Portugal, Spain, Tunisia, Turkey	Coleoptera: Cerambycidae	Eucalypt
Phyllaphis fagi	Albania, Croatia	Hemiptera: Aphididae	Beech
Pityogenes chalcographus	Croatia, Serbia	Coleoptera: Scolytidae	Spruce
Thaumetopoea bonjeani	Algeria, Morocco	Lepidoptera: Thaumetopoeidae	Cedar
Thaumetopoea pityocampa	Albania, Algeria, Bulgaria, Croatia, Morocco, Syrian Arab Republic, The former Yugoslav Republic of Macedonia, Tunisia, Turkey	Lepidoptera: Thaumetopoeidae	Pine
Thaumetopoea processionea	Croatia, Syria	Lepidoptera: Thaumetopoeidae	Oak
Thaumetopoea wilkinsoni	Cyprus, Israel, Lebanon	Lepidoptera: Thaumetopoeidae	Pine
Tomicus destruens	Cyprus, Tunisia	Coleoptera: Scolytidae	Pine
Tomicus piniperda	Cyprus, Lebanon	Coleoptera: Scolytidae	Pine
Tortrix viridana	Croatia, The former Yugoslav Republic of Macedonia, Tunisia	Lepidoptera: Tortricidae	Oak

Note: For the introduced insects – *Leptocybe invasa*, *Ophelimus maskelli*, *Phoracantha recurva* and *P. semipunctata* – the countries in bold type reported that pest in FAO (2010). In the other countries listed, the pest is known to have been introduced but it was not reported as a major outbreak

species. For the indigenous species, the countries listed are only those that specifically reported the pest as a major outbreak species.
Sources: Dhahri, Ben Jamaa and Lo Verde, 2010; FAO, 2010b.

Of the 27 insect pests reported, 13 were coleopterans (beetles), nine were lepidopterans (butterflies and moths), four were hymenopterans (sawflies and wasps), and one was a hemipteran (aphid).

Phloem and wood borers, such as *Ips*, *Phoracantha* and *Tomicus* species, are a problem in many countries in the Mediterranean region. Some of these represent a double threat, as they may act as vectors for pathogens. *Orthotomicus erosus*, for example, is a carrier of pathogenic fungi and is known to carry *Sphaeropsis sapinea*, which causes mortality in many *Pinus* species.

Defoliators such as the gypsy moth (*Lymantria dispar*) and processionary moths (*Thaumetopoea* species) are also a regional problem. *Thaumetopoea pityocampa*, for example, was reported in all Mediterranean countries except Egypt and Libya.

While native pests are clearly a problem, a number of high..profile insect pest species native to Australia are established in many Mediterranean countries, where they are causing considerable damage to forests. The following invasive pests were reported by numerous Mediterranean countries:

- *Leptocybe invasa* is a serious pest of *Eucalyptus* species in many countries in the Mediterranean region, particularly in young plantations. Developing larvae of this pest form galls on leaf midribs, petioles and stems of new growth of young eucalypt trees, coppice growth and nursery seedlings. Severely attacked trees show leaf fall, a gnarled appearance, loss of growth and vigour, and often decline and eventual death.
- *Ophelimus maskelli* is established in northern Africa, southern Europe and the Near East, where it causes considerable damage to *E. botyoides*, *E. camaldulensis*, *E. cinerea*, *E. grandis*, *E. robusta*, *E. rudis*, *E. saligna, E. tereticornis* and *E. viminalis* (Dhahri, Ben Jamaa and Lo Verde, 2010). This pest also induces galls on tree limbs and leaves and is so damaging that the establishment of *E. camaldulensis* plantations was abandoned in Israel (Mendel *et al.*, 2004).
- *Phoracantha recurva* and *P. semipunctata* are both serious borer pests of eucalypts, particularly those planted outside their natural ranges. *Phoracantha semipunctata* has caused major damage to plantations of *E. camaldulensis* in parts of North Africa and the Near East.

Two other introduced pests of great importance in the Mediterranean region (but which were not reported by more than one country) include the cedar web-spinning sawfly, *Cephalcia tannourinensis*, and the red gum lerp psyllid, *Glycaspis brimblecombei*.

The cedar forests of Lebanon, almost entirely composed of *Cedrus libani*, cover an area of approximately 1 700 ha, which is 2.8 percent of the country's total forest area. These cedar forests are of great importance in preserving the genetic diversity of the species and the primary source of globally widespread ornamental cedars. During the late 1990s, one of the largest of the 12 remaining cedar stands in Lebanon, the cedar forest of Tannourine, became severely infested by a new (to te stand) insect species, *Cephalcia tannourinensis*. This pest is extremely voracious and is considered to be among, if not the most, damaging insect to cedars. FAO provided emergency technical assistance to deal with this situation in

2001–2003. The pest continues to be monitored in all cedar forests in Lebanon in order to prevent outbreaks that could threaten the cedars in Lebanon and elsewhere in the Mediterranean region.

Originating from Australia, *Glycaspis brimblecombei* is a pest of eucalypt species that has been introduced to Mediterranean countries, including Italy (Laudonia and Garonna, 2010), Portugal, Spain (Hurtado and Reina, 2008; Valente and Hodkinson, 2009), and recently Morocco (Ibnelazyz, 2011). It can cause severe defoliation, decreased growth rates and mortality. It is of particular concern given its ability to spread rapidly once introduced.

Table 2.13 shows forest diseases reported by Mediterranean countries. *Cryphonectria parasitica*, or chestnut blight, was the most reported disease in the region. Originating in Asia, it has spread throughout the world including to Africa, the Near East, North America and large areas of Europe. It infects the above-ground parts of trees and creates cankers that expand, girdle and eventually kill tree branches and trunks.

Table 2.13. Diseases occurring in more than one country in the Mediterranean region

Pest	Countries	Main host
Cryphonectria parasitica	Albania, Bosnia and Herzegovina, Croatia, France, Greece, Italy, Portugal, Slovenia, Spain, The former Yugoslav Republic of Macedonia, Tunisia, Turkey	Chestnut
Melampsora allii-populina	Albania, France	Poplar
Microsphaera alphitoides	Albania, Croatia	Oak
Mycosphaerella pini	Croatia, France	Pine
Ophiostoma ulmi	Croatia, The former Yugoslav Republic of Macedonia, Tunisia	Elm
Seiridium cardinale	Albania, Cyprus, Israel	Cypress
Sphaeropsis sapinea	Croatia, France	Pine

Source: FAO, 2010b.

Seiridium cardinale is a serious fungal pathogen of cypress trees that causes branch and trunk cankers. It has been reported in all continents and is common in the Mediterranean region. The disease has caused the loss of millions of cypress trees, particularly in southern Europe, and is much more prevalent and severe in areas where cypress has been introduced.

Mycosphaerella pini is a fungus that infects and kills the needles of *Pinus* species. It is perhaps the most important foliage disease of exotic pines, although susceptibility among pine species varies. For example, *Pinus radiata* is particularly susceptible, and this disease has forced some managers to abandon the planting of this species.

Many of the insect pests and diseases reported in the region are pests of broadleaved trees, with six pest species alone attacking oak (tables 2.11 and 2.12). Twelve pine pests and four eucalypt pests were reported. In addition to the pests discussed above, dieback and decline have been observed in some areas of the Mediterranean region, such as in junipers (*Juniperus procera*) in Libya and cedars (*Cedrus atlantica*) in Morocco.

Other disturbances

Woody invasive species. Woody invasive species are becoming increasingly recognized as a major problem, with many negative economic, social and environmental impacts. Many non-indigenous tree species are used in agroforestry, commercial forestry and desertification control. Problems occur when these species become serious pests and the negative impacts outweigh the positive benefits arising from their use.

Table 2.14 lists the woody invasive species reported in the Mediterranean region in 2010. The majority were *Acacia* species, which are often introduced for the supply of timber, woodfuel and building materials; for animal fodder; for tannins used by leather industries; and for afforestation and sand stabilization. Where they have become invasive, acacias have altered wildlife habitats and nutrient cycles, decreased water supplies for nearby communities, and increased the fire hazard.

Table 2.14. Woody invasive species reported in the Mediterranean region

Pest	Countries
Acacia cyanophylla	Cyprus
Acacia dealbata	Spain
Acacia salicina	Israel
Acacia saligna	Israel
Acacia spp.	Portugal, Spain
Acacia victoria	Israel
Acer negundo	France, Spain
Ailanthus altissima	Bulgaria, Cyprus, Italy, Spain
Amorpha fruticosa	Bulgaria, Croatia
Dodonaea viscosa	Cyprus
Fraxinus americana	Bulgaria
Gleditsia triacanthos	Spain
Parkinsonia aculeata	Israel
Prunus serotina	France
Robinia pseudoacacia	Croatia, Italy, Slovenia

Source: FAO, 2010b.

A native plant of China, *Ailanthus altissima* is a significant invasive plant in the Mediterranean region. It is a very aggressive, fast-growing tree and a prolific seeder that can overrun native vegetation. It also produces toxins that prevent the nearby establishment of other plant species.

Robinia pseudoacacia is a highly adaptable, aggressive species that is native to the southeastern United States of America. It propagates easily by seed, coppice and root suckers and spreads readily into new areas, where its shade reduces competition from other plants.

Other biotic disturbances. Other biotic factors reported in the countries of the Mediterranean region include parasitic plants such as mistletoe species, *Loranthus europaeus* and *Viscum album* (Croatia, The former Yugoslav Republic of Macedonia); weeds (Croatia); pruning by humans for fodder (Albania); rodents (Cyprus and Croatia); wildlife and cattle grazing (Albania, Croatia, Cyprus and Egypt); and macaques (Morocco).

Abiotic disturbances. Abiotic disturbances (*i.e.* disturbances caused by non-living factors) have considerable impacts in Mediterranean forests (Table 2.11). In some areas, the damage caused to forests by storms (*e.g.* wind, snow and ice) has increased in recent decades, particularly in Europe, where storms cause more than 50 percent of all damage to forests. Storm damage was reported in Croatia, Cyprus, France, Lebanon and Morocco. Croatia also reported damage due to landslides and floods.

Droughts occur when there is less than normal precipitation over an extended period of time, usually a season or more. Often associated with the arid regions of Africa, in recent years such events have also struck India and parts of China, the Near East, Australia, parts of North America, South America and Europe, as well as the Mediterranean (WMO, 2011). Drought can affect forests in a variety of ways, including through increased mortality, productivity declines and dieback, and increased susceptibility to insect pests and pathogens. Both Croatia and Israel reported drought as a significant abiotic disturbance affecting their forests.

2.3 Good and services provided by Mediterranean forest ecosystems

Wood products in Mediterranean forests

Mediterranean forests may be distinguished less by the wood they provide than by their non-wood forest products (NWFPs) and ecosystem services (Merlo and Croitoru, 2005), but they do contribute to meeting regional demand for wood products. Data on wood production, consumption and trade in the Mediterranean are at the national level and do not distinguish between forest types. Care is therefore needed in their interpretation, especially for the northern Mediterranean region, which includes significant volumes of products derived from both Mediterranean and non-Mediterranean forests.

The need for wood products varies widely in the Mediterranean region

For the following analysis, apparent consumption per capita has been calculated to establish and compare the requirements for wood products. A simplified definition of apparent consumption was used that ignores changes in stock, for which there are no available data. Figure 2.35 show that, in general, the highest levels of apparent consumption per capita of wood and wood products were in the northern Mediterranean subregion (see Figure 2.36 for the subregional groupings used in this section).

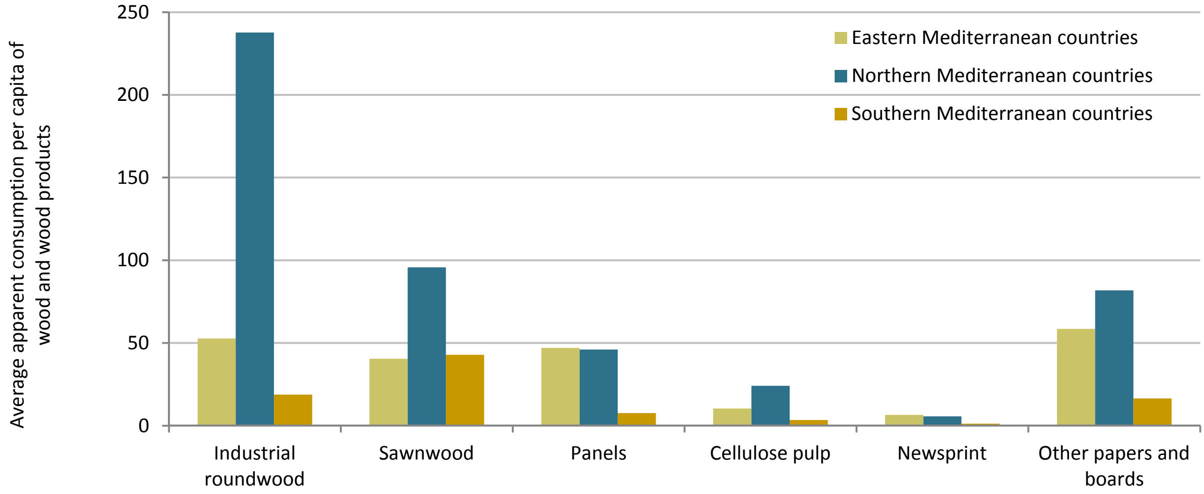


Figure 2.35. Average apparent consumption per capita of wood and wood products in Mediterranean subregions, 2010.
Note: Pulp, other papers and boards are expressed in tonnes per capita; other values are in m^3 per capita.
Sources: FAOSTAT, 2010; UNECE/FAO, 2012.

The similar level of consumption of wood-based panels in the eastern Mediterranean and northern Mediterranean subregions is explained by the relatively high consumption by the construction sectors in Israel and Turkey. Consumption varies depending on the type of panel: eastern Mediterranean countries consume mainly plywood, fibreboard and particleboard, while panel consumption in northern Mediterranean countries is dominated by particleboard, mainly for furniture manufacturing. The consumption of all wood products except sawnwood is decreasing in southern Mediterranean subregion.

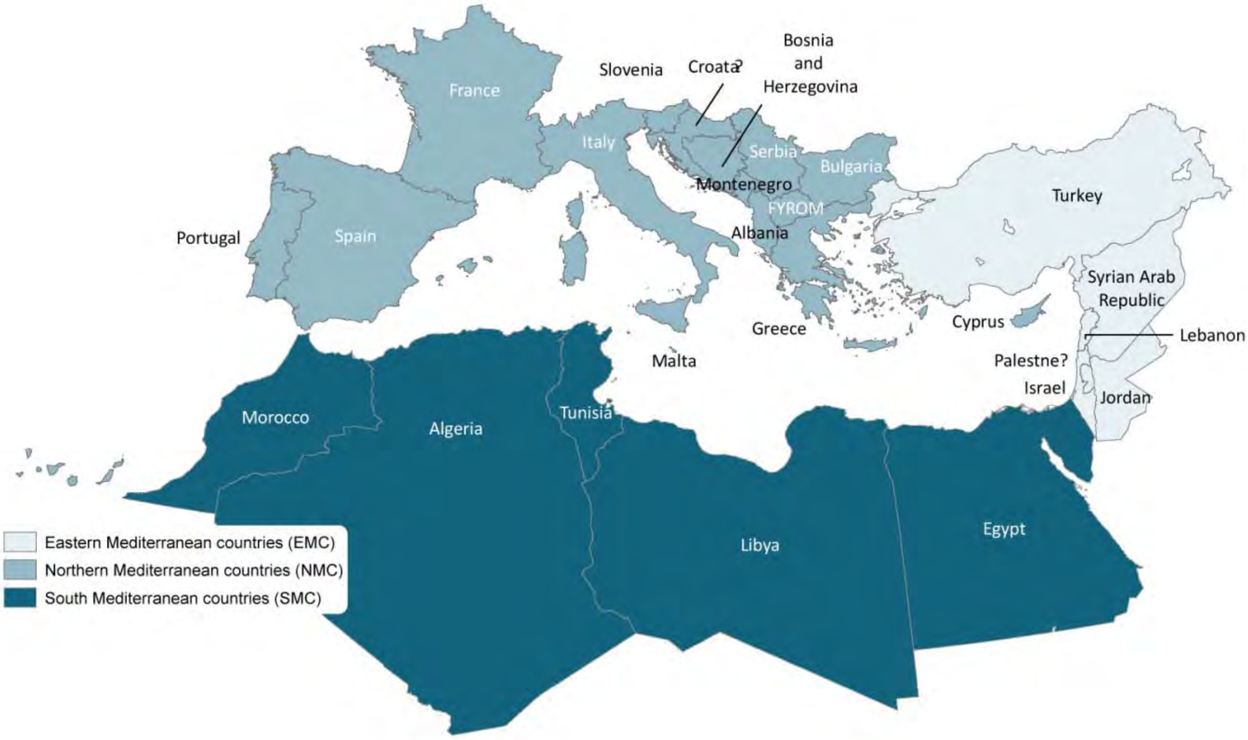


Figure 2.36. Mediterranean countries, grouped into three subregions
Source: FAO.

Production is concentrated in northern Mediterranean countries

The production of industrial wood in countries of the Mediterranean region amounted to 84 million m^3 in 2010 (56 percent of which was softwood), representing 5.5 percent of world production. The production of woodfuel was similar – nearly 82 million m^3, which was 4.4 percent of world production. Sawnwood production was about 23 million m^3, which was 5.8 percent of world production, and the volume of panels constituted 8.3 percent of world production. The production of paper and paperboard was 35 million tonnes (8.8 percent of world production), and pulp production was 7 million tonnes (4 percent of world production; Table 2.15).

Northern Mediterranean countries dominated all areas of production (from both Mediterranean and non-Mediterranean forests), especially roundwood, pulpwood and derived products (Figure 2.37). Eastern Mediterranean countries make a significant contribution to the production of fibreboard. Turkey is the main producer of fibreboard in the Mediterranean, at 3.3 million m^3 per year. Thus, depending on the product, production in the eastern Mediterranean countries was between 5 percent and 50 percent of the production of northern Mediterranean countries. In general, production is low in the southern Mediterranean countries, except for woodfuel, which constitutes one-third of total production in the subregion.

The production of woodfuel is important in the Mediterranean (*e.g.* Box 2.3), although it is difficult to quantify, especially in the southern and eastern subregions where a significant quantity is consumed or marketed through informal channels. In addition, recent political events and socio-economic developments in the region have changed the way in which woodfuel is collected, which is also not reflected in official data. Efforts to improve data on woodfuel are under way in some countries, such as France, Serbia and Slovenia. Methods applied in these countries could usefully be extended to the rest of the Mediterranean region.

Table 2.15. Production of wood and wood products in the Mediterranean region, by subregion, 2010

Product	Eastern Mediterranean countries	Percent of all Mediterranean countries	Northern Mediterranean countries	Percent of all Mediterranean countries	Southern Mediterranean countries	Percent of all Mediterranean countries	Total Mediterranean countries
Industrial roundwood (broadleaved) (1 000 m^3)	9 564	20	37 961	80	205	0	47 730
Industrial roundwood (conifers) (1 000 m^3)	6 207	17	29 365	81	872	2	36 444
Total industrial roundwood (1 000 m^3)	15 771	19	67 326	80	1 077	1	84 174
Woodfuel (broadleaved) (1 000 m^3)	1 964	16	4 516	37	5 878	48	12 358
Woodfuel (conifers) (1 000 m^3)	3 246	5	43 711	62	23 357	33	70 315
Total woodfuel (1 000 m^3)	5 210	6	48 227	58	29 235	35	82 673
Coniferous sawnwood (1 000 m^3)	4 000	25	11 953	75	70	0	16 022
Broadleaved sawnwood (1 000 m^3)	2 261	35	4 186	64	90	1	6 537
Total sawnwood (1 000 m^3)	6 261	28	16 139	72	160	1	22 560
Plywood (1 000 m^3)	261	17	1 185	76	106	7	1 551
Particleboard (1 000 m^3)	3 179	21	11 811	78	88	1	15 078
Fibreboard (1 000 m^3)	3 314	49	3 440	51	33	0	6 787
Total wood-based panels (1 000 m^3)	6 754	29	16 435	70	227	1	23 416
Cellulose pulp (1 000 tonnes)	65	1	6 458	95	262	4	6 785
Newsprint (1 000 tonnes)	35	2	1 760	98	4	0	1 799
Other papers and boards (1 000 tonnes)	5 934	18	26 436	79	994	3	33 365
Total newsprint, other papers and boards (1 000 tonnes)	5 969	17	28 197	80	998	3	35 164

Sources: FAOSTAT, 2010; UNECE/FAO, 2012.

Figure 2.37. Total production of roundwood, sawnwood and panels (top) and total production of cellulose pulp, newsprint, other papers and boards (bottom), Mediterranean region, 2010
Sources: FAOSTAT, 2010; UNECE/FAO, 2012.

Box 2.3 Use of woodfuel in Morocco

Fuelwood constitutes 30 percent of energy consumption in Morocco. Whether burnt as raw wood or converted to charcoal, woodfuel is the second largest source of energy after petroleum products and the first in terms of national production. In 2004, the Moroccan High Commission for Water and Forestry and the Combat against Desertification estimated that the consumption of wood energy easily surpassed the productive capacity of vegetation and that it was making a major contribution to deforestation and widespread ecosystem degradation (Figure 2.38). The rate of deforestation was estimated at 225 000 m3, which corresponds to approximately 30 000 ha/year.

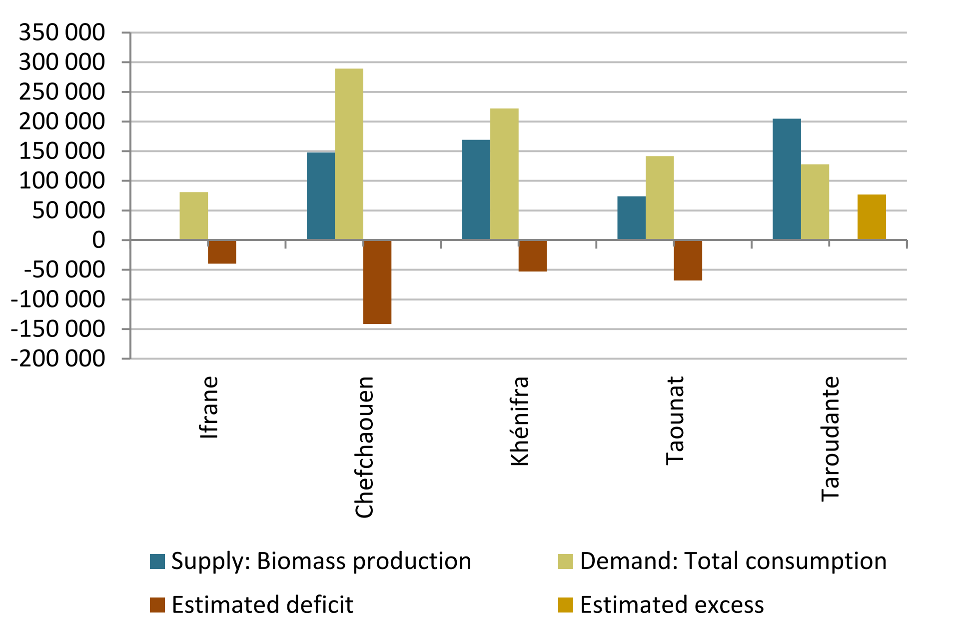


Figure 2.38 Woodfuel consumption in Morocco by province, 2004

The Moroccan Centre for Development of Renewable Energies found that the provinces of Chefchaouen, Ifrane and Khénifra lacked sufficient alternative energy resources to reduce the pressure on forests for the next 2–3 decades. Rural populations and especially the poorest people will continue to depend mainly on plant-based fuels that are immediately available in their environment. This situation will persist until there is widespread access to substitute energy resources.

Trade in the Mediterranean is dominated by imports

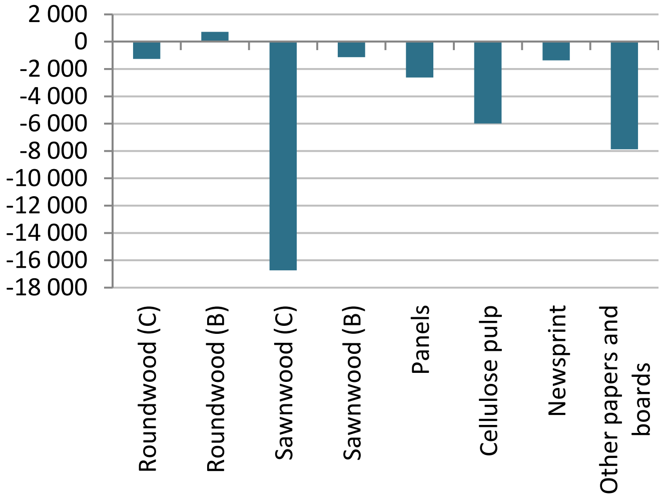
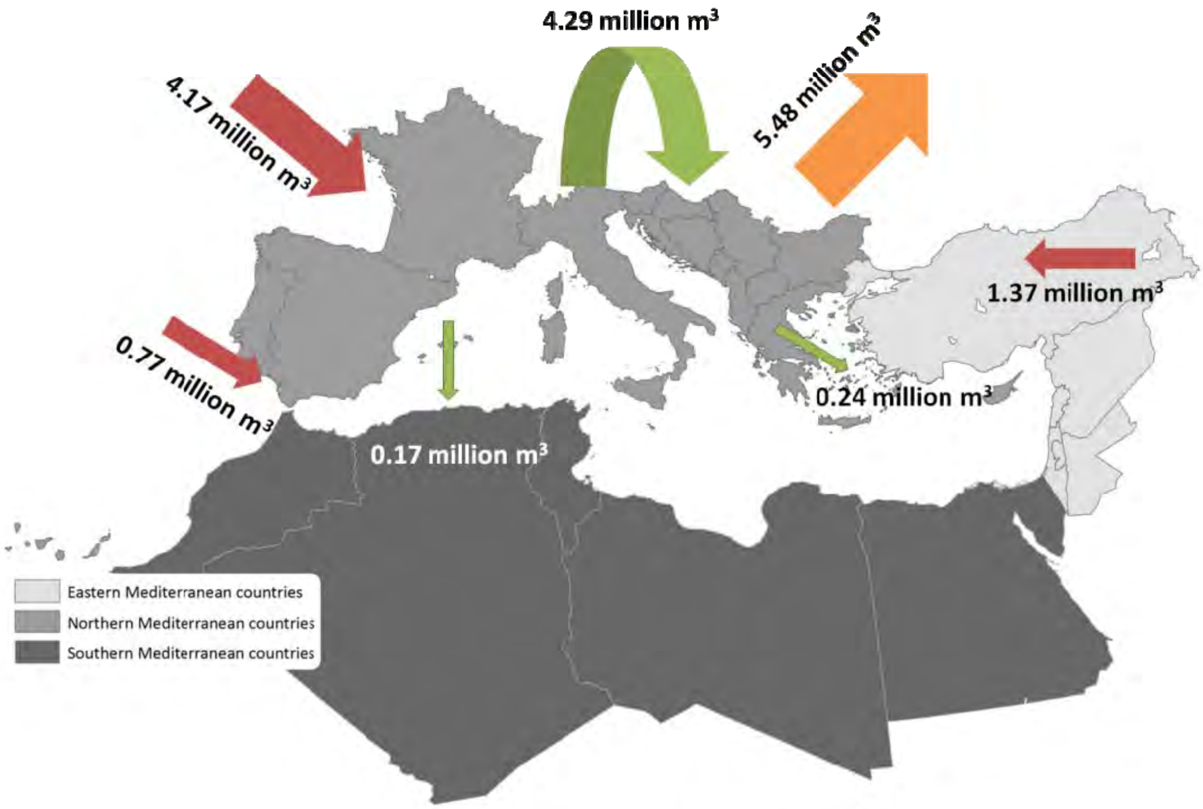


Figure 2.39. Global trade of wood and wood products in the Mediterranean region, 2010
Note: y axis values are in thousand m^3 except for pulp, newsprint and boards, which are in 1 000 tonnes; intra-Mediterranean fluxes are excluded; B = broadleaved; C = conifers.
Sources: FAOSTAT, 2010; UNECE/FAO, 2012.

The Mediterranean region is a net importer of wood and wood products. In 2010, the region collectively imported wood and wood products to the value of more than US$40 billion, US$32 billion of which (80 percent) was from non-Mediterranean countries (Figure 2.39). The largest values for imports were for conifer sawnwood, pulp and derivatives (Figure 2.40). As shown in Figure 2.41, imports are increasing.



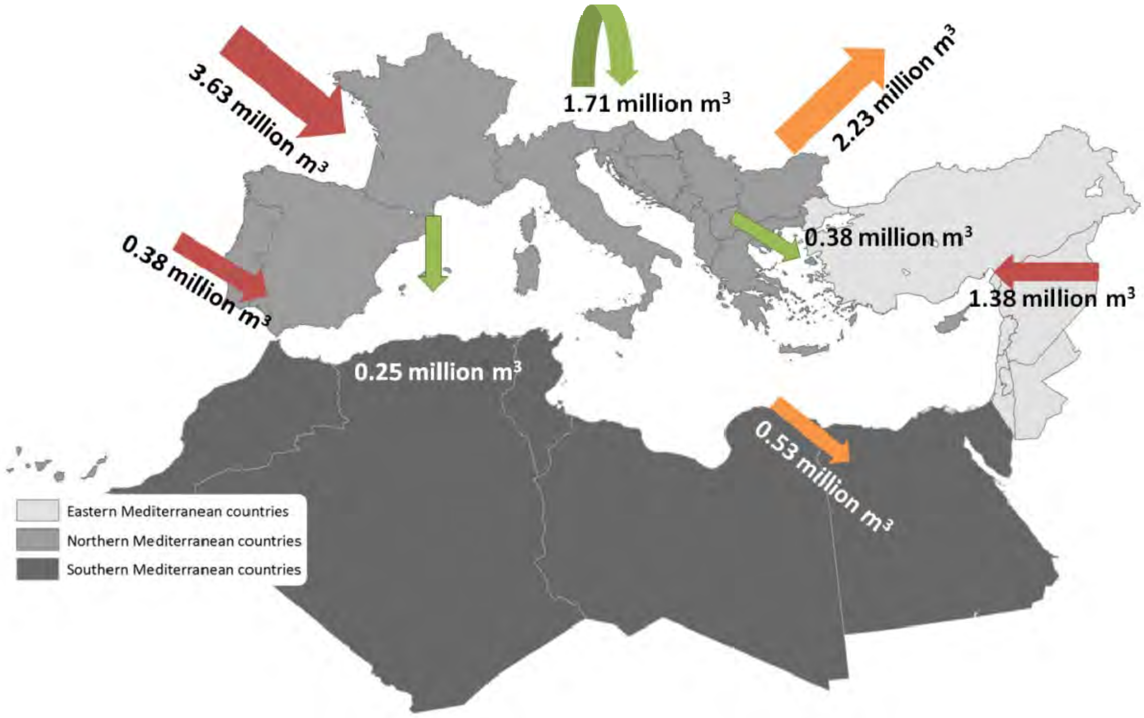


Figure 2.40. Representation of flows of roundwood (top) and wood-based panels (bottom), in the Mediterranean region and with other regions of the world, 2010.
Note: Green arrows = imports from Mediterranean countries; red arrows = imports from non-Mediterranean countries; orange arrows = exports to non-Mediterranean countries.
Sources: FAOSTAT, 2010; UNECE/FAO, 2012.

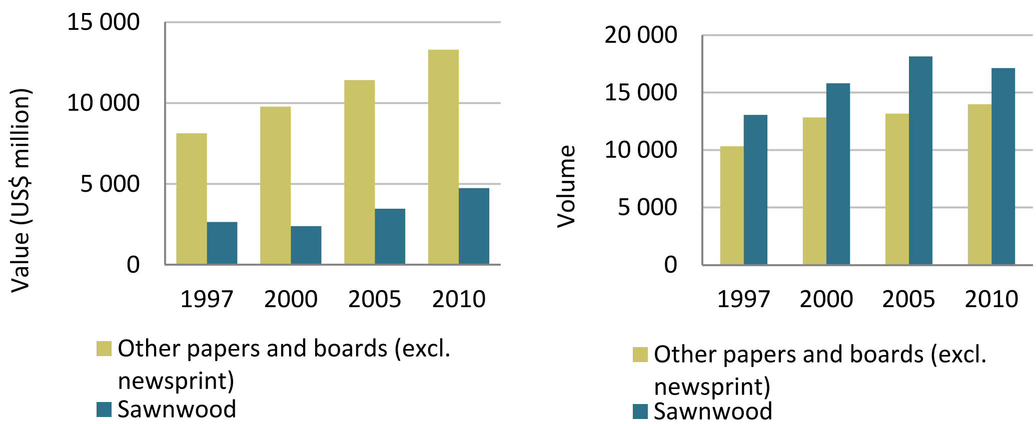


Figure 2.41. Changes in volume and value of imports of sawnwood, pulp and boards (newsprint excluded) to the Mediterranean region
Note: in right-hand figure, units are 1000 tonnes for other papers and boards (excl. newsprint) and 1000 m^3 for sawnwood.
Source: FAOSTAT, 2010; UNECE/FAO, 2012.

Exports of conifer sawnwood from the EU to North Africa decreased by 14 percent between 2010 and 2011, probably as a consequence of the “Arab Spring”. This trend was also observed in other products such as panels, for which increases were recorded but did not reach the levels attained prior to the Arab Spring.

Only industrial broadleaved roundwood achieved a positive trade balance (by volume) in 2010, although this was due mainly to production in non-Mediterranean forests in northern Mediterranean countries. Wood and wood products imported by Mediterranean countries mainly originate in non-Mediterranean regions. Within the region, only northern Mediterranean countries are exporters, and they provide a significant proportion of the total roundwood, panels, newsprint and boards imported by southern and eastern Mediterranean countries. Except for limited exports of panels and newsprint, the contribution of southern and eastern Mediterranean countries to intra-Mediterranean trade is negligible.

Conclusion

The production of wood and wood products in the Mediterranean region (Mediterranean and non-Mediterranean forests combined) is far from negligible. This production supplies markets within the region, with trade mainly from northern Mediterranean countries in the southern and eastern subregions. Nevertheless, this trade is insufficient to meet the needs of the region, which is a net importer of wood and wood products.

Most countries in the southern and eastern Mediterranean subregions are importers and produce only small volumes of wood and wood products. On the other hand, some northern countries (mainly France, Italy, Portugal and Spain) are both producers and importers of certain products. Turkey, an importer and exporter of panels, belongs in this last category, while the Balkan countries occupy an intermediate place, being characterized by modest production that may be extremely important at the local level.

Non-wood forest products

Cork oak forests

Cork oak forests are characteristic components of Mediterranean landscapes. Worldwide, they cover about 2.5 million ha, almost all of which is in the Mediterranean countries of Algeria, France, Italy, Morocco, Portugal, Spain and Tunisia (Figure 2.42).

Cork oak forest landscapes are typically mosaics of mixed forest habitat types and woodlands, scrub communities, pastures and extensive agriculture, and they have high economic and cultural relevance. Shaped by human activities over millennia, cork oak forests coexist with agriculture and traditional practices and provide a broad range of goods and services, such as cork, woodfuel, pasturage, forage, aromatic herbs, mushrooms, beekeeping, nature tourism and leisure activities associated with rural areas.

Despite the strong link with human intervention, cork oak forest landscapes are biologically very diverse: 60–100 flowering plant species can be found in one-tenth of 1 ha (Figure 2.43).

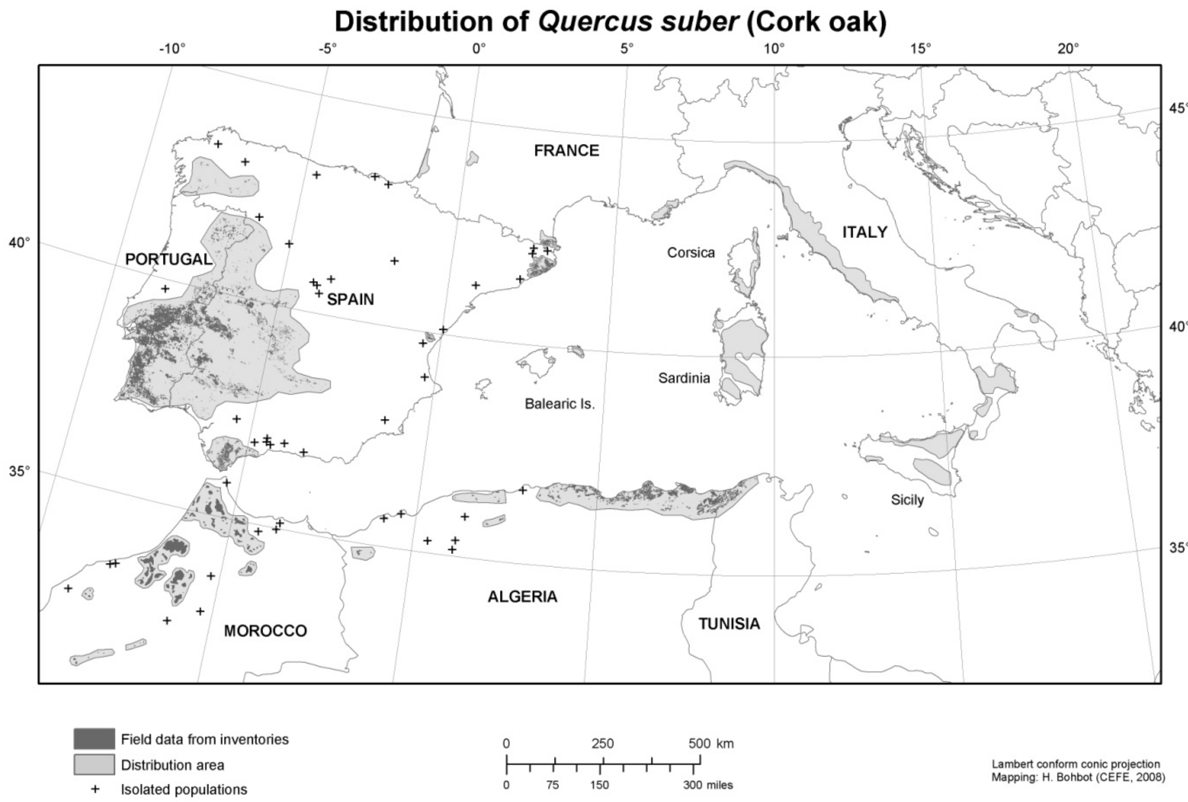


Figure 2.42. Distribution map of cork oak forests in the Mediterranean region
Source: Aronson, Pereira and Pausas, 2009. Reproduced by permission of Island Press, Washington, DC, USA.

Figure 2.43. Cork oak woodlands. ©APCOR 2006

The tree. Cork oak (*Quercus suber*) is a long-lived (200 years or more) evergreen oak. It can survive adverse conditions of both human and natural origin – *e.g.* cutting, grazing, prolonged drought and fire – but not extreme cold. Its outer bark is characterized by suberized dead cells that form a compact, elastic, impermeable and thermally insulating tissue up to 30 cm thick (Natividade, 1950; Pereira, 2007). Cork oak trees produce a new cork ring each year that is not shed naturally. This feature has evolved as an adaptation to periodic fire, which is common in the Mediterranean region (Pausas, 1997). The trees survive and produce new cork when the original bark is removed. The first cork harvest is conducted when the tree is approximately 30 years old. Thereafter, harvests are practised at 9–12-year intervals, which is sufficient time for the trees to grow a new layer of cork about 3 cm thick.

Biogeography. Today, cork oak is found only in the warmer parts of the humid and subhumid western Mediterranean. It occurs predominantly from Morocco and the Iberian Peninsula to the western rim of Italy, but also in scattered areas in southern France and the coastal plains and hills of Algeria, Morocco and Tunisia (Figure 2.44). Cork oak forests cover almost 1.5 million ha in Europe and 700 000 ha in North Africa. Its fragmented distribution suggests that it is mainly relictual. Overgrazing (which limits regeneration), the replacement of cork oak by eucalypt and pine plantations, the expansion of plow agriculture in managed woodlands, incautious cork stripping, and the extraction of tannins have contributed to diminish the distribution and vitality of the cork oak forest estate.

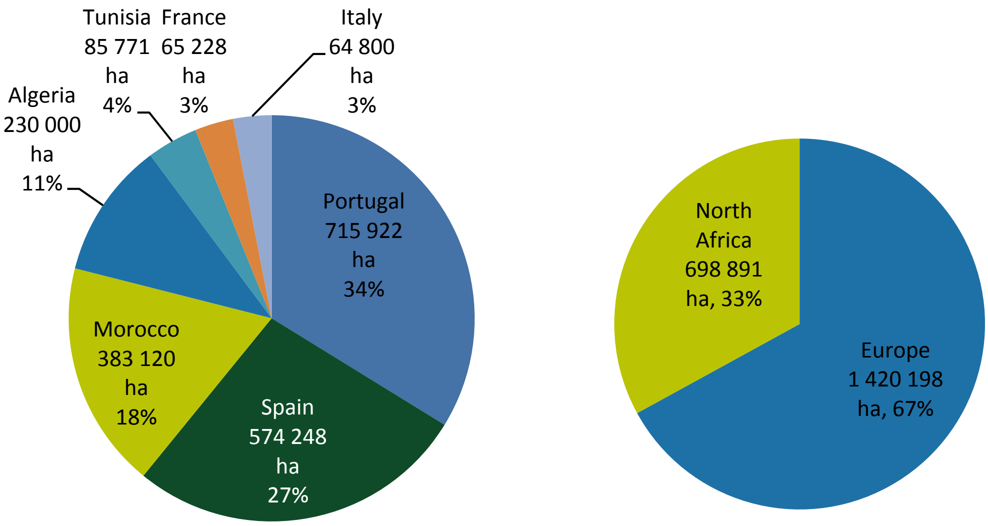


Figure 2.44. Area of cork oak forest, by country and continent, and percentage of global distribution, 2008
Source: APCOR, 2012.

Cork oak was introduced to some countries outside the Mediterranean region in the twentieth century as an ornamental plant or with the aim of producing cork products. Reasonably good results, but not successfully developed industries, have been obtained in Bulgaria, California, Chile, New Zealand, southern Australia and Turkey.

Figure 2.45 shows that there was a substantial increase in the area of cork oak forest in southwestern Spain and in Portugal between 1893 and 2006, but declines in Algeria, France and Italy.

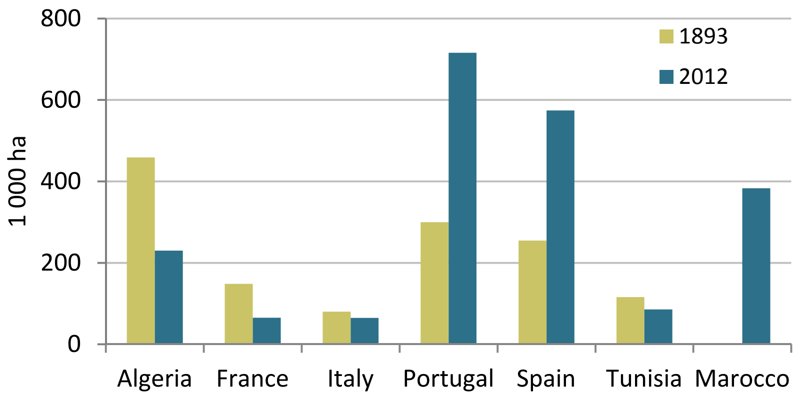


Figure 2.45. Cork oak forest area, by country, 1893 and 2012
Note: No data were available for Morocco for 1893.
Sources: Lamey, 1893; APCOR, 2012.

Cork production and export. Portugal is the main producer of cork (50 percent of total production), followed by Spain, Italy, Algeria, Morocco, Tunisia and France (Figure 2.46). Algeria, Morocco and Tunisia produce 14 percent of total production.

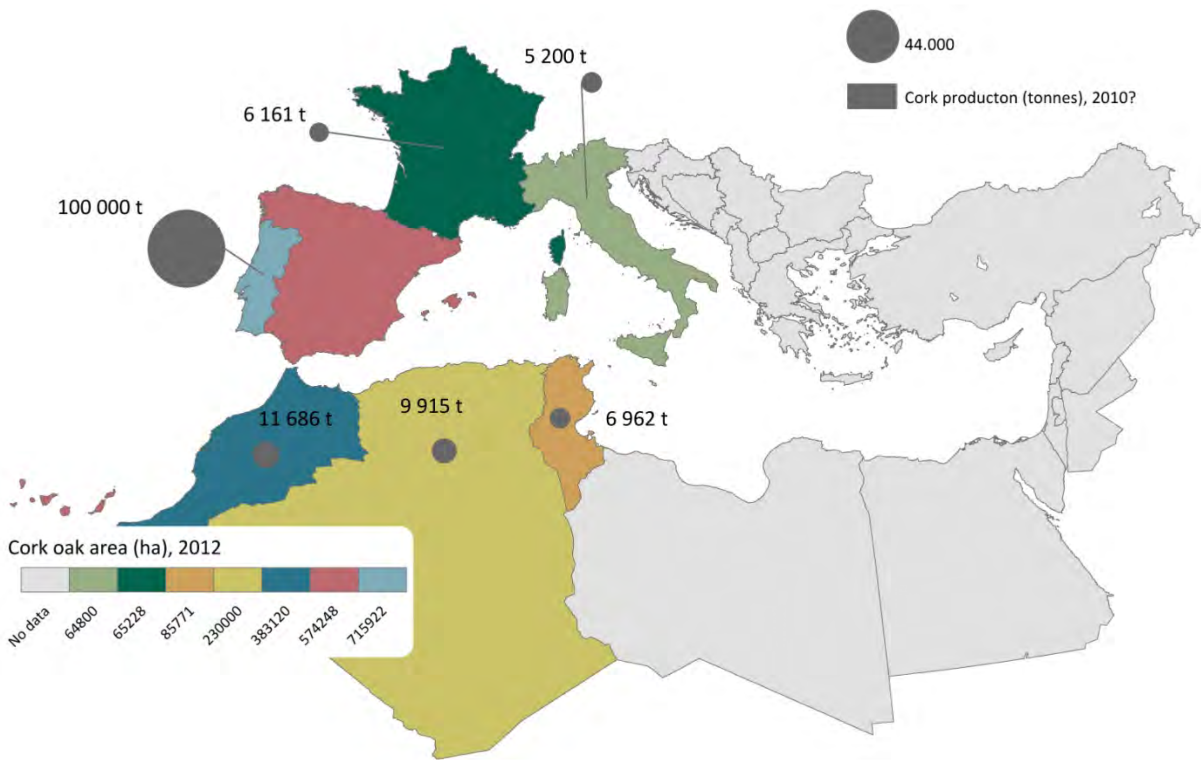


Figure 2.46. Estimated cork oak forest area and cork production in Mediterranean countries
Sources: APCOR, 2012.

The cork stoppers market is considered the backbone of the cork industry, representing 70 percent of total economic value (Natural Cork Quality Council, 1999). For example, 44 percent of annual Portuguese production is used in the manufacture of stoppers (Figure 2.47) (see Box 2.4). Other uses include as pavement, flooring and insulation material (*e.g.* the external fuel tanks of NASA's Space Shuttle) and in clothes, accessories and decorative objects. Globally, cork is the sixth-most important NWFP. In 2011, the estimated annual export value of cork was €1.3 million, while processed cork products generate approximately US$2 billion in annual revenue (APCOR, 2012). Figure 2.48 shows the top cork importers and exporters.

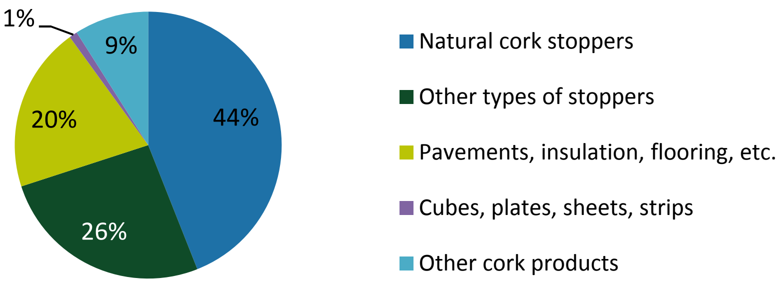
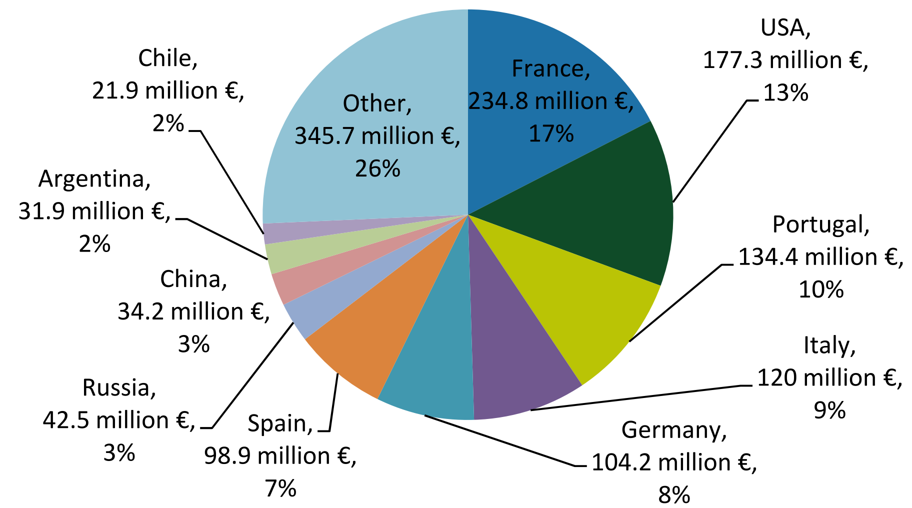


Figure 2.47. Portuguese cork's product destination, 2010
Source: Portuguese Cork Association, 2011.



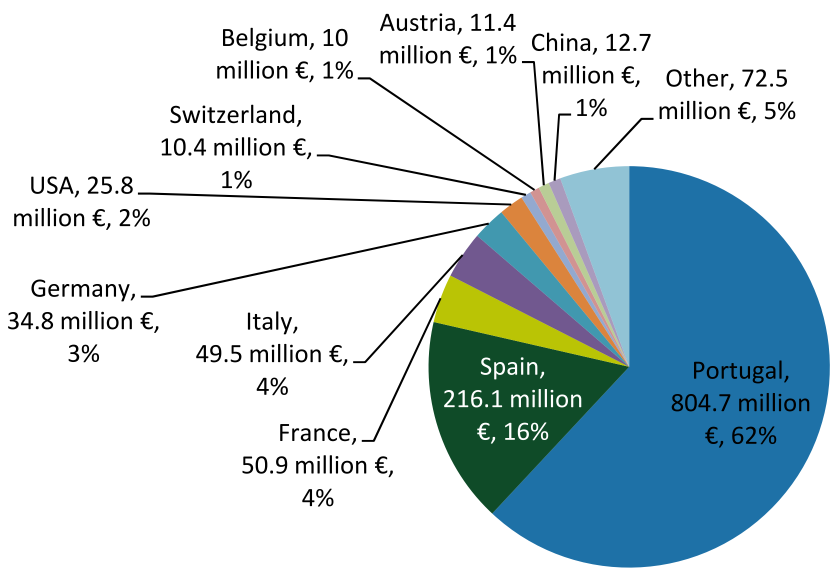


Figure 2.48. World's top countries for the export and import of cork, 2011
Source: APCOR, 2012.

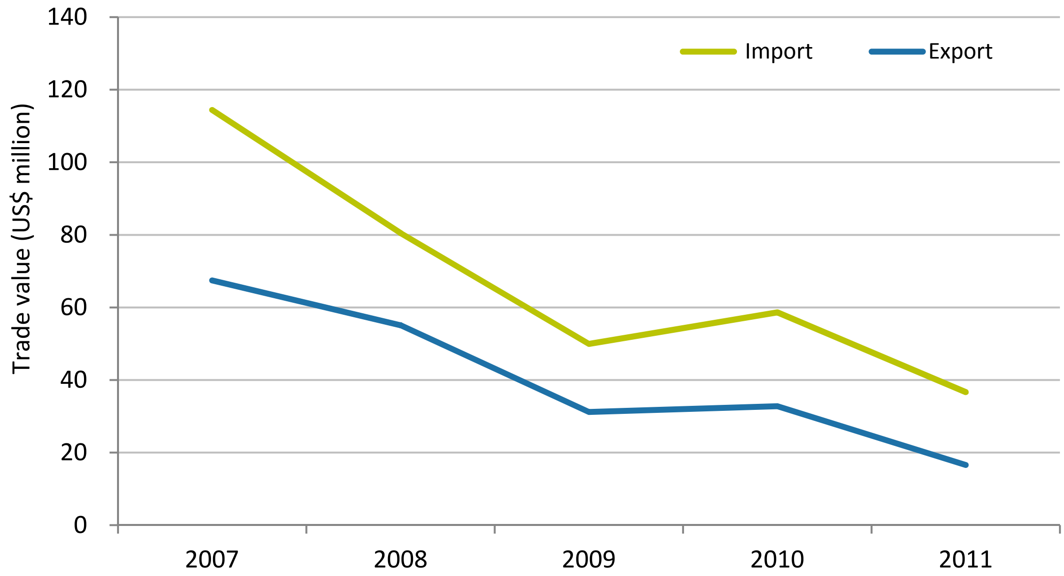


Figure 2.49. Global import and export of cork products, 2007–2011
Source: United Nations International Merchandise Trade Statistics, 2011.

In recent years, synthetic stoppers and metal screw-caps have competed with traditional cork stoppers in the marketplace and contributed to a market devaluation of cork (Aronson, Pereira and Pausas, 2009). Prices declined by approximately 30 percent between 2003 and 2009 and there were declines in the total value of imports and exports (Figure 2.49).

Box 2.4 The war of stoppers

Cork is an ideal material for sealing wine: it is light-proof, waterproof and rot-proof and combines low density with high elasticity. The manufacture of stoppers represents nearly 80 percent of the value of the total cork crop (Figure 2.50 and Table 2.18).

Figure 2.50. Artigianal cork stopper production, Spain. ©Pilar Valbuena

After several centuries of total domination of the stopper market, cork has recently faced strong competition from alternative materials. In the period 2000–2007, for example, cork was not used for 4 billion of the total global market of 16.7 billion stoppers. Reasons for the decline include:

- concerns related to TCA (2,4,6-trichloroanisole), the molecule mainly responsible for ''cork taint'' (manufacturers recently invested heavily in processes to eradicate TCA);
- a decrease in wine production due to the passage from quantitative-type consumption limited to countries with a strong wine tradition (southern Europe) to a geographically broader and more qualitative consumption, but quantitatively limited;
- the rise of new wine-producing regions (America, Oceania) that are technologically inclined to use alternative systems and where cork is not a cultural issue.

Cork has unquestionable qualities: it is the only natural, renewable, recyclable and biodegradable corking. The harvesting of cork oak increases the amount of stored carbon due to the continuous stimulation of cork production (a cork stopper fixes two times its weight in carbon dioxide). These environmental qualities can be marketed through forest certification, which is now applicable to Ns such as cork. The indication on wine bottles of the type of stopper used, which would not be mandatory but strongly recommended in order to respond to the concerns of consumers interested in the cork tradition, remains a topic under discussion.

Table 2.16. Estimated global sales of cork stoppers, 2007

Stopper type	Billions of stoppers	%
Total cork stoppers	12.2	73
of which		
Naturals	3.3	20
Colmated	1.25	7
Agglomerated	1.8	11
Treated	1	6
1+1 technical cork	2.4	14
Champagne and sparkling wine	1.8	11
Capsulated cork closures	0.65	4
Total substitutive stoppers	4.5	27
of which		
Synthetic	2.9	17
Screw cap wine	1.6	10
All stoppers	16.7	100

Note: Colmated cork stoppers are natural cork stoppers made from more porous natural cork. Treated cork stoppers are a new generation of agglomerated cork stopper obtained by the agglutination of cork granules bonded with flexible glue from a process of moulding with 51% of the cork granules (by weight) with a granulometric size of 0.25–0.8 mm. This cork is prepared using a procedure intended to reduce the organoleptic neutrality and which can contain synthetic materials. Capsulated cork closures are natural cork stoppers with a range of different caps in plastic, wood and other materials, designed for bottling fortified wines and spirits. 1+1 technical cork stoppers have a very dense agglomerate cork body with natural cork disks glued on at one or both ends.
Source: Institut Méditerranéen du Liège, 2008.

Box 2.5. New sustainable uses of cork in the context of climate change mitigation: cork and green building

Cork oak is highly adapted to warm temperatures and drought, but climate change could affect the adaptive capacity of cork oak forest ecosystems. Some climatic models predict a latitudinal and altitudinal shift of cork oak distribution, resulting in the fragmentation of cork oak forests in southern areas (*e.g.* the Maghreb and Andalusia), and the colonization of new areas in the north (*e.g.* in France, Portugal and Castile in Spain).

On the other hand, cork oak forests mitigate climate change at the local level, limiting evaporation from the soil and influencing the water cycle. Due to its longevity and the cyclic removal of bark, cork oak stocks large amounts of carbon dioxide and is a moderate water-user. Moreover, cork harvesting has a low environmental impact, and well-managed stands have a relatively low risk of wildfire, partly because fire trails are well-maintained and thus allow the quicker and more effective intervention of fire-fighting services.

Cork oak forest management can facilitate adaptation to climate change through the use of a dynamic and innovative silviculture that mixes tree species and favours gene flow. The development of eco-certification should also allow the identification of cork oak products from sustainably managed forests, with possible market advantages. The management of cork oak forests is one of the most important economic forest-related issues in the Mediterranean region, which historically has been funded by the production and sale of cork stoppers. In the future, the cork industry may need to diversify.

One of the best examples of a new use of cork is green building, which can combine many positive characteristics of cork for climate change mitigation: it is a natural and renewable forest material that stores carbon, it can be produced sustainably, with high environmental values, and it can reduce energy use in buildings due to its insulating (*e.g.* the Portugal Pavilion at the World Expo in Shanghai, China) qualities and durability (floor covering of Sagrada Familia in Barcelona, Spain).

The future of cork forest landscapes. Although information is scattered, cork oak forests face several interrelated threats. Overgrazing, woodfuel collection, fast-growing plantations (often driven by subsidies for agriculture and forest plantations), poor forest management practices, fire, land abandonment, desertification and uncontrolled urban development are affecting the survival and health of cork oak forests. Climate change (*i.e.* increasing aridity and rainfall unpredictability) and pests and diseases are additional factors.

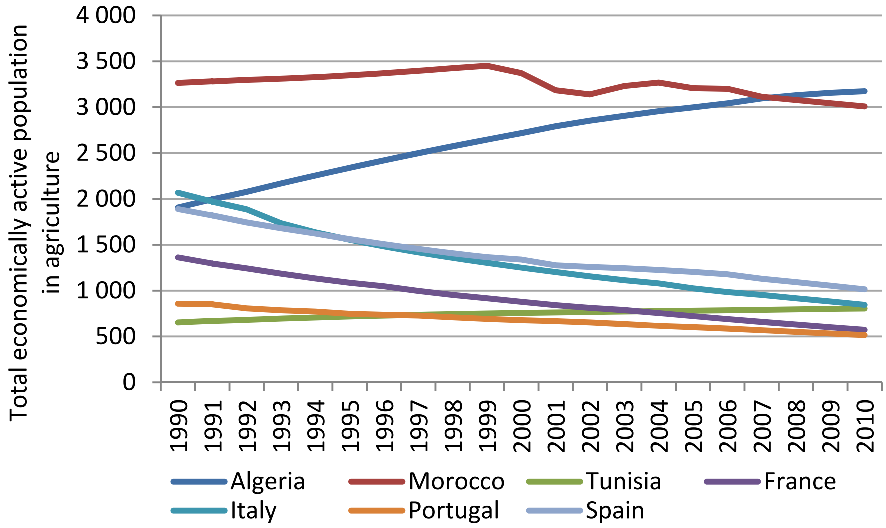


Figure 2.51 Trend in economically active population in agriculture in cork-producing Mediterranean countries
Source: FAOSTAT, 2010.

Figure 2.51 shows that the size of the "active rural population" – economically active persons engaged in agriculture, hunting, forestry or fishing – is decreasing in southern Europe but increasing in Algeria and Tunisia (Figure 2.51). Land abandonment and the loss of traditional land-use systems are widespread in most of Mediterranean Europe. Although the EU supports agriculture through programmes and subsidies (*e.g.* direct payments to farmers, subsidizing exports; Kleijn and Sutherland 2003), declining revenues are increasing the abandonment of cork oak forests in southwestern Europe. In the absence of management, shrubby understorey proliferates in these ecosystems, increasing the risk of severe wildfire (Joffre *et al.*, 1999) and the loss of habitat heterogeneity and conservation value. Moreover, subsidies can promote conversion to fast-growing forest plantations and other uses and unintentionally facilitate the loss of biodiversity.

In contrast, human overuse of cork oak forests is common in North Africa, where the resource is mainly owned by the state but exploited intensively by local people (*e.g.* for woodfuel collection and grazing) for subsistence purposes. Since cork is a state-owned product, few people are able to obtain legal income from its harvest, favouring the illegal market.

Good practices to conserve and promote cork oak landscape conservation. Various innovative tools are available and, in some Mediterranean countries, are being applied to promote good practices in cork oak forest management.

Developing markets for products from sustainably managed cork oak forests is a way to encourage the adoption of best practices. In 2012, in Italy, Portugal and Spain, 147 748 ha of cork oak forests had been certified by the Forest Stewardship Council (unpublished data provided by FSC), and certification processes are under way in Morocco and Tunisia (Berrahmouni *et al.*, 2009). Pilot interventions to restore and improve the management of degraded forests and ecosystems through forest landscape restoration in Portugal and Morocco are supporting local communities, landowners, managers and non-governmental organizations to implement best practices for managing large areas of cork oak forest.

Conclusion. Mediterranean cork oak forests are ecosystems of high conservation value that provide a wide range of important goods and ecosystem services. Although cork oak forests are the result of centuries of human management, today they face substantial socio-economic change and may be threatened by climate change. Innovative conservation and management approaches are important for conserving biodiversity and the multifunctionality of these fragile, human-shaped ecosystems. Continued effort is needed to encourage sustainable practices and to prevent the overexploitation of natural resources, land abandonment and biodiversity loss.

Stone pine in Mediterranean forests

The stone pine, *Pinus pinea* L. (Figure 2.52), with its umbrella-shaped crown, is a highly characteristic element of many Mediterranean landscapes. It occurs as isolated trees and in lines and small rural groves in open farmland, and also forms forests. Native stone pine-dominated forests and woodlands are usually not extensive, but they are distributed widely across the Mediterranean region. The species fulfils an important role in watershed and soil protection (*e.g.* dune stabilization), due to its capability of rooting in bare sands and dry environments where few other woody species can grow.

Native open stone-pine dominated woodlands constitute habitats for endangered species such as lynx, wolf, imperial eagle, black vulture, peregrine falcon and black stork. The ecological succession facilitated by stone pine from bare, mobile sands to mature pine and oak forests has been well documented. The presence of isolated pines, tree lines and small groves is a structural element in rural landscapes, interrupting as evergreen tree islands the uniformity and large expanse of Mediterranean farmland and playing an important ecological role by providing food, roosting and nesting sites, refuges and passageways for many animal species, especially birds.

Figure 2.52. Mediterranean stone pines, Spain
© Sven Mutke

Geographic distribution. The natural range of stone pine is unknown due to its early expansion since the Neolithic throughout the Mediterranean region (Figure 2.53). At least in southern France and in Spain, Mediterranean stone pine was an integral element of the open woodland and steppe habitat dynamics of the late Quaternary before and during the Last Glacial Maximum (50 000–18 000 BCE), when its large, nut-like edible seeds were gathered as an easy-to-store, highly nutritive (50 percent fat, 35 percent protein) staple food by Neanderthals and modern humans. Evidence for the human consumption of Mediterranean pine nuts since the Middle Palaeolithic has been found in charcoal remnants in Neanderthal caves, Neolithic rock paintings at Holocene archaeological sites in Portugal, Spain, Turkey and Lebanon, and in ancient Egyptian funeral offerings, and is extensive since Greek and Roman Antiquity.

Stone pine can grow in natural or naturalized forests, often mixed with Maritime pine (*Pinus pinaster*), Aleppo pine (*P. halepensis*), holm oak (*Quercus ilex*), cork oak (*Q. suber*) and junipers (*Juniperus* species), without understorey or accompanied by coppices of various species and by other Mediterranean trees and shrubs (*e.g. garrigue* and *maquis* types). The species can also occur in pure even-aged or uneven-aged stands, the former often derived from planted forests. The species was widely used in the nineteenth and twentieth centuries for the afforestation of dunes and bare, stony slopes in France, Italy, Portugal, Spain and Turkey. It has also been planted and become naturalized in Algeria, Argentina, Chile, Israel, Iran, Morocco, South Africa and Tunisia, and in some cases it is considered an invasive species.

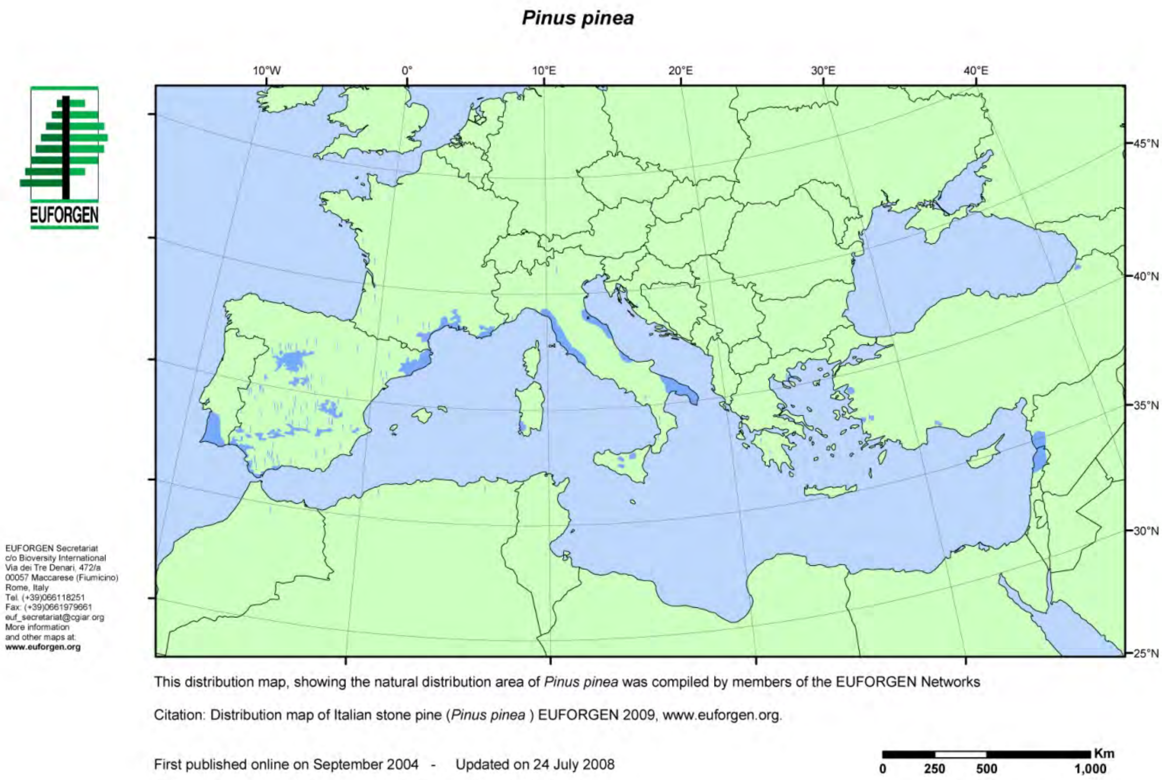


Figure 2.53. Natural distribution of *Pinus pinea* L., Mediterranean region
Source: EUFORGEN, 2009.

Stone pine is often associated with coastal or inland sandy zones, such as the Tagus and Sado estuaries in Portugal, the inland dunes of the Middle Douro Basin, the area around the Doñana National Park in the Guadalquivir estuary in Spain, the Petite Camargue in the Rhone estuary in France, the Tuscan and Adriatic coasts in Italy, and the Strofylia Forest in Southern Greece. Another typical habitat is bare rocky slopes, especially on poor siliceous parental rocks like granite, gneiss, sandstone and schists. Examples of this habitat are found in the Spanish Central System, the Sierra Morena, northern Portugal, and on Mount Lebanon, and occasionally on calcareous rocks, such as on the Maures Plain near Cote d'Azur in France and the Spanish La Mancha.

Currently, stone pine forest covers more than 0.75 million ha in the Mediterranean region, scattered from the Atlantic coast in Portugal to the shores of the Black Sea and Mount Lebanon. The main areas are in France, Italy, Lebanon, Portugal, Spain, Tunisia and Turkey (Figure 2.54).

Estimating the area of these forests is difficult because of the frequent presence of mixed forests and forest–shrub mixtures. In some cases, young recent plantations are included. For example, most reviews estimate that Portugal has 50 000–70 000 ha of stone pine forests, but the current National Forest Inventory generated an estimate of about 130 000 ha, due to a shift in forest management away from an emphasis on growing maritime pine for timber (a species heavily affected by pine nematode), towards nematode-resistant stone pine and cork oak, which produce non-wood products (pine nuts and cork) of high commercial value. Consequently, the area of stone pine forest has increased in Portugal by more than 50 000 ha, not only due to new plantations but also to the removal (by active elimination or mortality) of the formerly dominant maritime pines from mixed stands. The Portuguese production of pine nuts has increased several-fold, often using agroforestry approaches in the resultant open stone pine stands. Similarly, in Spain, the area of stone pine forest has increased in the last 20 years, mainly on retired farmland at the initiative of private land owners and stimulated by European Common Agricultural Policy subsidies. In Turkey and Lebanon, stone pine trees planted outside forests are common and account for a significant proportion of total cone production.

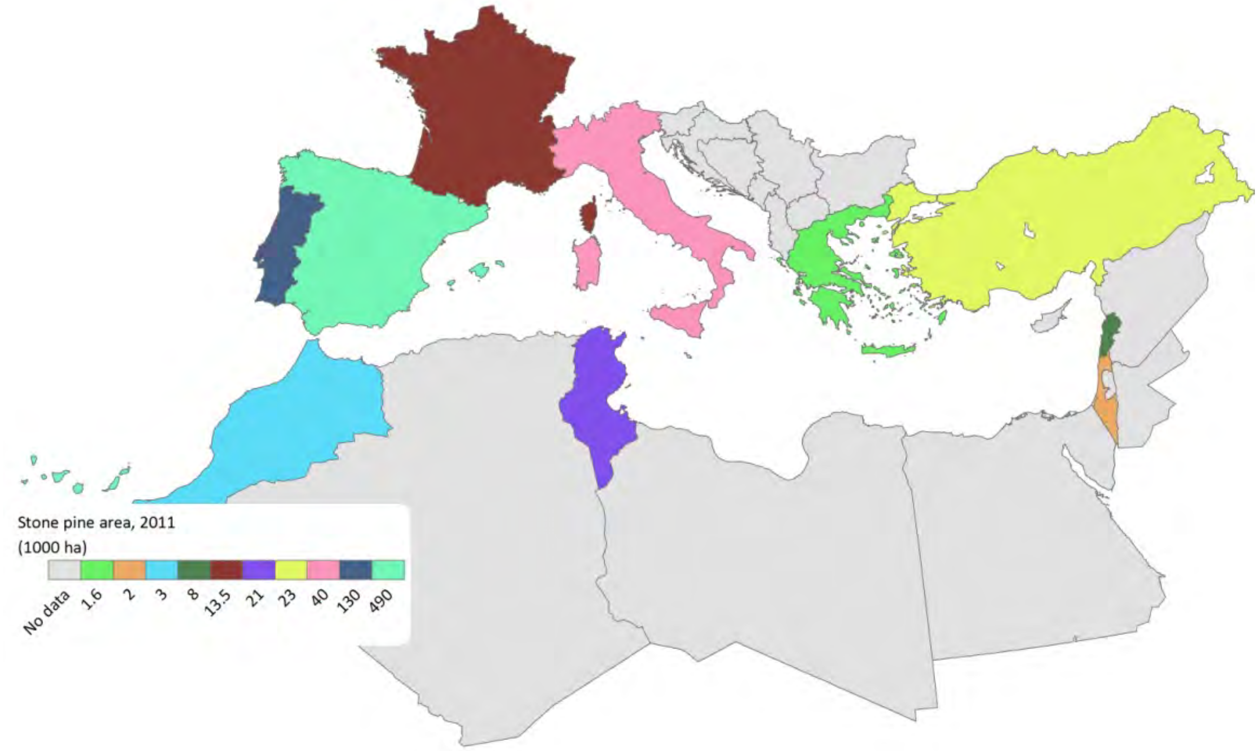


Figure 2.54. Stone pine areas in Mediterranean countries, 2011
Source: Agropine, 2011.

Cones and pine nut production from stone pine forests in the Mediterranean region.
Until recently, the commercial cone harvest in stone pine forests was carried out by tree-climbers in late autumn and winter, using iron hooks on 3–6 m long poles to dislodge the ripe but still-closed cones. Each tree-climber can collect about 300–450 kg cones per day. It can be a dangerous job, however, because it involves climbing high up in trees, often in very cold and wet conditions. In the last decade, harvesting machines have started to be used. These machines work by vibrating the trees to dislodge the cones, working in a similar way to the tree-shakers used in olive harvesting.

In Spain, the stumpage price of pine cones is €0.25–0.30 per kg and the factory price is €0.50–0.80. At these prices, the cones are now the most important product yielded by stone pine forests, providing forest owners with an income of about €50–60 per ha per year (for a cone yield of 200 kg per ha per year, although the most productive areas in Portugal and Lebanon can produce 4–7 tonnes per ha per year). This is higher than the revenue from timber (€20–30 per ha per year), woodfuel, and other products or uses (for example, hunting and grazing rights each generate revenues of less than €5 per ha per year). In mixed stands with cork oak, the cork yield renders higher revenue – up to €200 per ha per year. Nevertheless, in most Mediterranean forests, production is limited by site quality and is subordinate to ecological and social functions, particularly soil and watershed protection, biodiversity conservation, scenic beauty and recreational use. Other traditional (but not always sustainable) activities in stone pine forests in the past were resin-tapping, the extraction of needle litter, which was used as bedding for animals, and even pine bark stripping for tanneries, but none of these is practised today.

Although stone pine is said to have been cultivated since the Neolithic for ornamental purposes and for its seed, it has never been properly domesticated as a nut crop. There are no defined cultivars, a fact that might be related to the species' extremely low genetic diversity. Nearly all the current stone pine nut production derives from forests where no cultivation techniques are applied, other than silvicultural practices that regulate stand composition and density. Thus, stone pine is basically a wild-collected species, and only in recent decades have increasing efforts been dedicated to clone selection, with production in grafted orchards. Mediterranean pine nuts have been highly appreciated as a gourmet food since Classical times, and they have gained recent attention as a health food. Demand is high, and since the cost of harvest is high and supply cannot meet demand, wild-collected pine nuts are among the world's most expensive nuts. The current price in international markets is €25–30 per kg for shelled pine nuts and the retail price is €40–60 per kg. The price is relatively inelastic, whereas the market is very elastic, absorbing all supply.

Mediterranean pine nuts shares the characteristic of being a forest nut rather than an agronomic crop with more than 20 other pine species with large, edible kernels worldwide, including Asiatic and American species of five-needle stone pines and the American pinyon pine. The true Mediterranean pine nut is one of the top four most commercially valuable pine nut species, together with *Pinus koraiensis* in East Asia, *P. sibirica* in Siberia and *P. geradiana* in the northwestern Himalaya. Annual world production of shelled pine nuts comprises 15 000–30 000 tonnes of kernels from China, the Russian Federation and the Republic of Korea (mainly *P. koraiensis* and *P. sibirica*), most of which is traded by Chinese distributors; 2 000–10 000 tonnes of Chilgoza pine nuts (*P. gerardiana*) from Pakistan and Afghanistan; and 6 000–9 000 tonnes of Mediterranean pine nuts (Table 2.17). These numbers are only approximate because accurate statistics are seldom available, or they are based on import–export data that do not account for domestic or local consumption. For example, Lebanon is only a minor exporter of stone pine nuts because of high domestic consumption, but in less than 10 000 ha of stone pine forest (including plantations) it produces a similar volume to Spain in its stone pine forest of nearly 0.5 million ha (which includes recent plantations and protective forests where there is no cone harvesting), due to a very favourable climate. In Spain, annual cone production can vary widely (up to fivefold) due to mast seeding and climate-related impacts such as those caused by drought and frost. Spain is estimated to produce, on average, about 1 500 tonnes of stone pine cones per year, compared with Portugal (3 500 tonnes), Lebanon (1 500 tonnes), Turkey (1 250 tonnes) and Italy (1 000 tonnes). In the last two decades, there has been a yield decline in Italy, possibly due to a shift in forest management towards closed old growth and an increased incidence of cone pests.

Another source of uncertainty in the data on stone pine cone production is that the data are often derived from processing or trading centres such as those in Italy and in Catalonia and Castile-Leon in Spain, which may be conflated with estimates made in the regions of origin. A good deal of cone harvesting is done by local, often family enterprises and by freelance workers. In the Castile-Leon region, for example, the public register for stone pine cone harvesting, processing and trading includes about 300 enterprises. Regional industries are increasingly organized in processing and trading cooperatives, and this is stimulating moves toward the standardization of the product and of processing and packing quality. The UNECE standard concerning the marketing and commercial quality of pine nuts (1993) has been under revision since 2011, with the aim of taking into account the differences among the various pine nut species and the consequences of the health problem known as pine mouth syndrome, which can be caused by the consumption of Chinese pine nuts (International Nut and Dried Fruit Foundation, 2012).

Table 2.17. Estimated worldwide production of various species of pine nut

Country	Species	Shelled kernel (tonnes)
Mediterranean countries	*Pinus pinea*	6 000–9 000
China	*P. koraiensis, sibirica* and others	5 000–12 000
Russian Federation	*P. sibirica, koraiensis*	8 000–17 000
Republic of Korea	*P. koraiensis*	1 500–2 000
Pakistan/Afghanistan	*P. gerardiana*	2 000–10 000
USA	*P. edulis* and others	500
World		30 000–40 000

Sources: Simonov and Dahmer, 2008; Pinenut.com; International Nut and Dried Fruit Foundation, 2011, 2012; Agropine, 2011.

Other non-wood forest products

Mushrooms, cork, pine nuts, chestnut, honey and truffles are among the most important NWFPs in the Mediterranean region. The impressive diversity of species that characterizes the Mediterranean region offers potential for the production of a wide variety of NWFPs. Some countries in the Mediterranean region have specific legislation for some NWFPs, such as cork, but generally a lack of a clear definition hinders the regulation of NWFP cultivation, extraction and exportation (for example, in Greece the only officially recognized NWFP is resin).

Several classifications of NWFPs are available. The data presented here follow the classification proposed by FAO (2010), in two main categories – animal and plant products (Table 2.118). Data provided by countries are sometimes very detailed (*e.g.* botanical names are provided) and sometimes incomplete. Thus, NWFP removals are likely to be underestimated.

Table 2.18. NWFP categories

Category	
Plant products/raw material	Animal products/raw material
Food	Living animals
Fodder	Hides, skins and trophies
Raw material for medicine and aromatic products	Wild honey and bee-wax
Raw material for colorants and dyes	Wild meat
Raw material for utensils, handicrafts and construction	Raw material for medicine
Ornamental plants	Raw material for colorants
Exudates	Other edible animal products
Other plant products	Other non-edible animal products

Source: FAO, 2010b.

Figure 2.55 shows the total volume of NWFP removals in the Mediterranean region in 2005. There were strong differences between the northern, southern and eastern subregions (which may be due partly to the quality of data provided by countries).

The categories for which countries provided most information were "food" and "raw material for medicine and aromatic plants" (Figure 2.56). The food category accounted for 42 percent of total NWFP removals in the Mediterranean countries (Figure 2.57), followed by hides, skins and trophies (29 percent) and other plant products (15 percent).

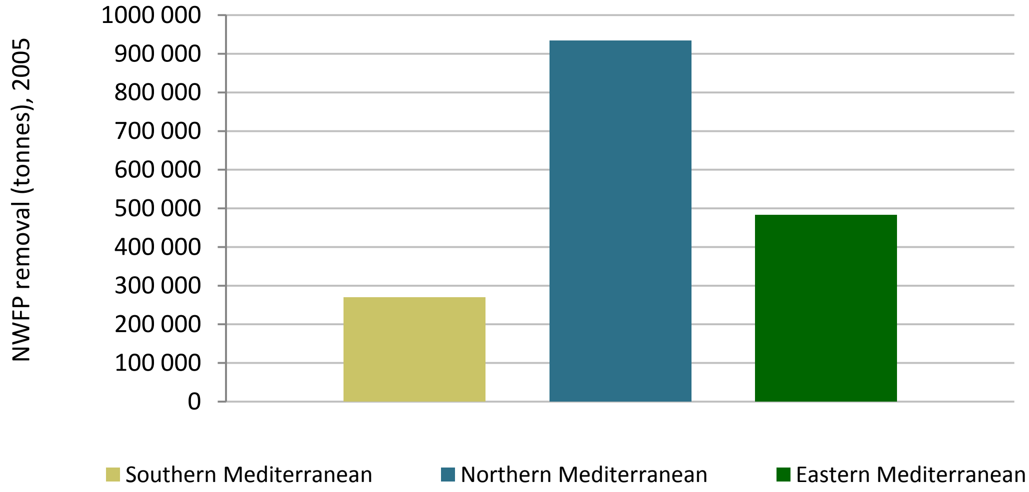


Figure 2.55. NWFP removals in the Mediterranean region, 2005
Source: FAO, 2010b.

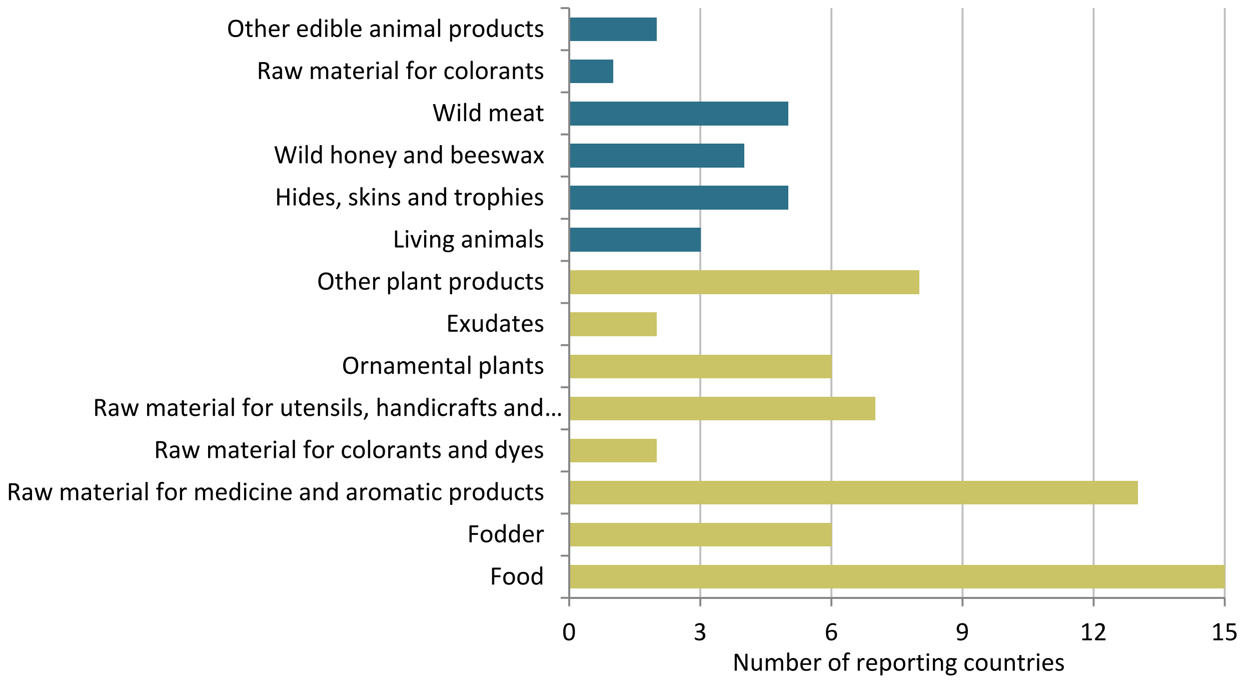


Figure 2.56. Information availability on NWFP removals, 2010
Source: FAO, 2010b.

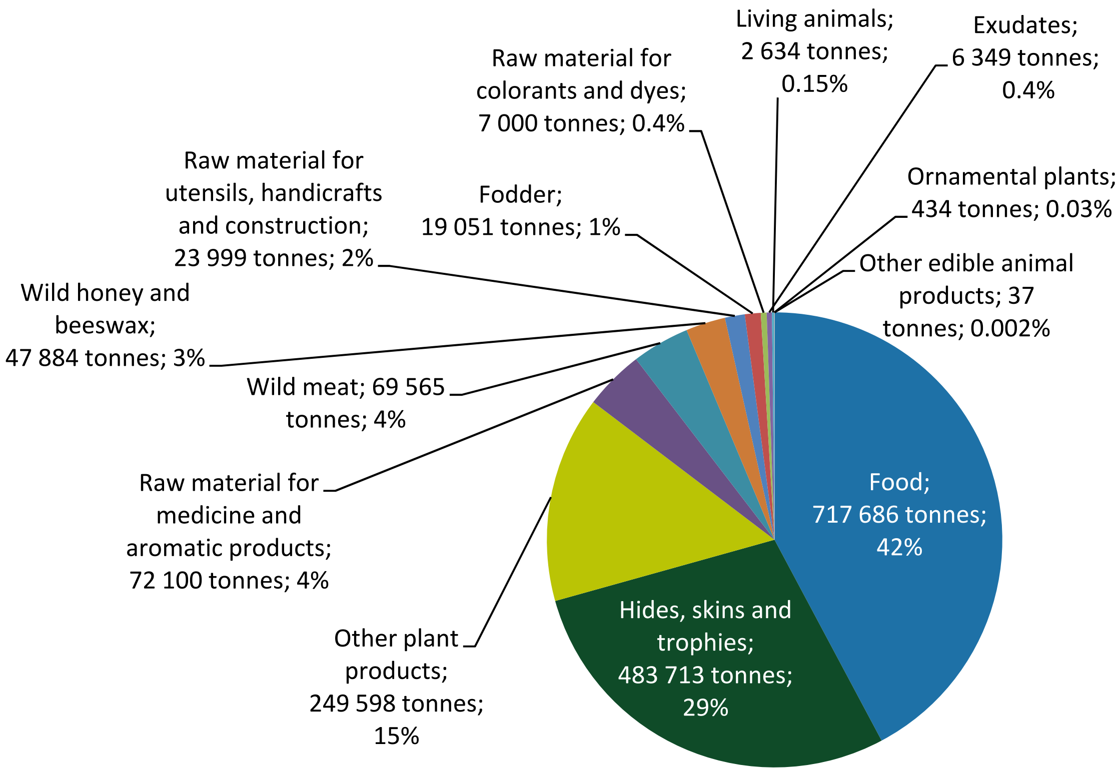


Figure.2.57. NWFP removals in the Mediterranean countries, 2010
Source: FAO, 2010b.

Northern countries produced almost 90 percent of the total Mediterranean harvest of NWFPs in the food category. Eastern countries produce mainly animal products (wild meat, hides, skins and trophies), while raw material for colorants, medicines and aromatic products were produced predominantly in southern countries (Figure 2.58). Figure 2.59 shows the relative importance of NWFP categories in France, Italy, Portugal and Spain.

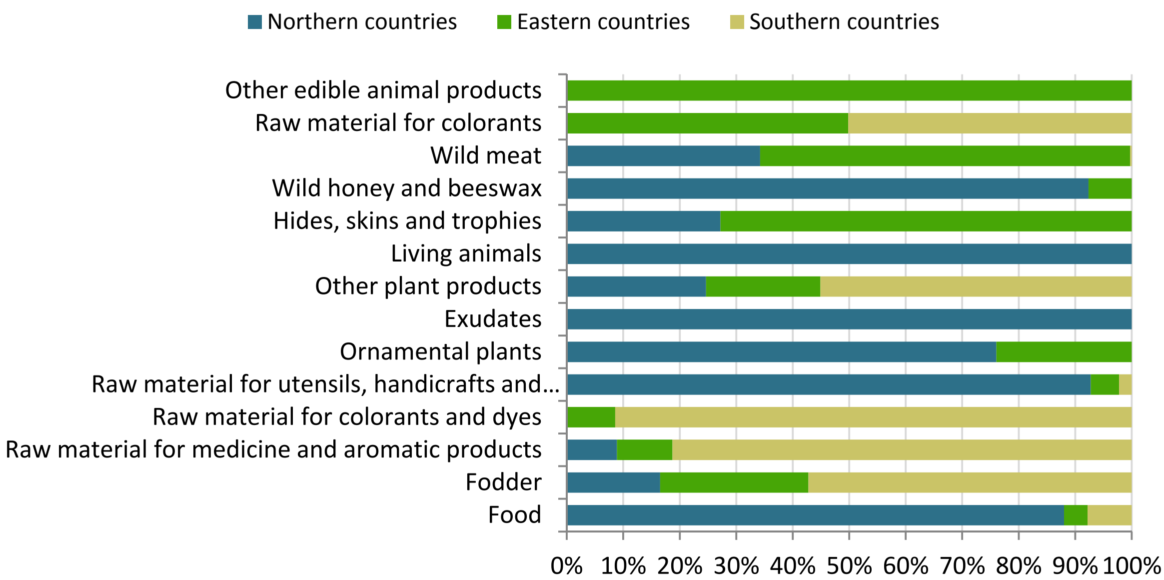


Figure 2.58. Percent of various categories of NWFPs provided by northern, eastern and southern countries, 2005
Source: FAO, 2010b.

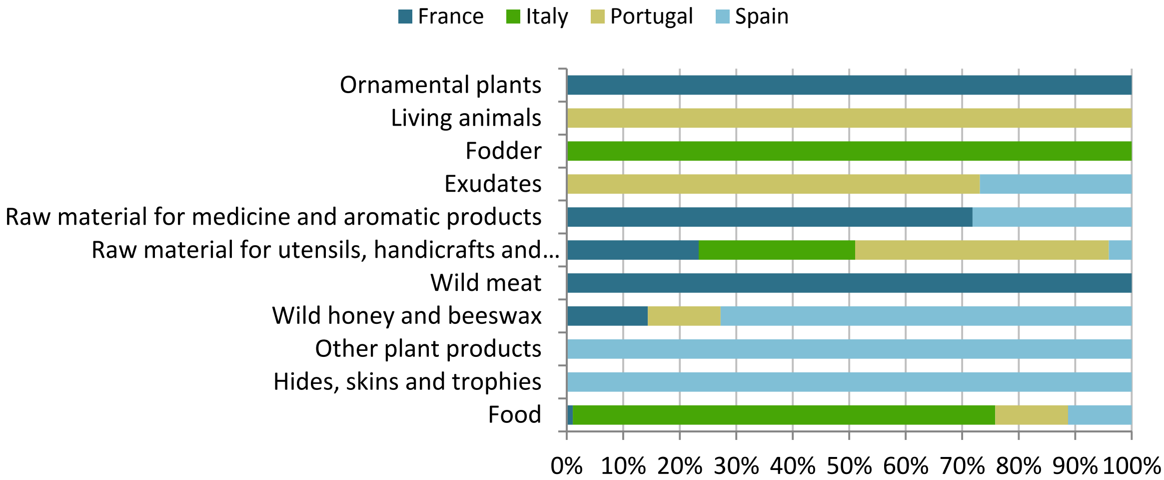


Figure 2.59. Percent of various categories of NWFPs provided by northern Mediterranean countries, 2010
Source: FAO, 2010b.

In eastern Mediterranean countries in 2005, hides, skins and trophies accounted for 31 percent of total NWFP production (352 000 tonnes), other plant products for 10 percent (50 500 tonnes) and wild meat for 9 percent (45 600 tonnes). The main producer of NWFPs in the eastern countries was Serbia, which provided 82 percent of the total amount by weight (Figure 2.60).

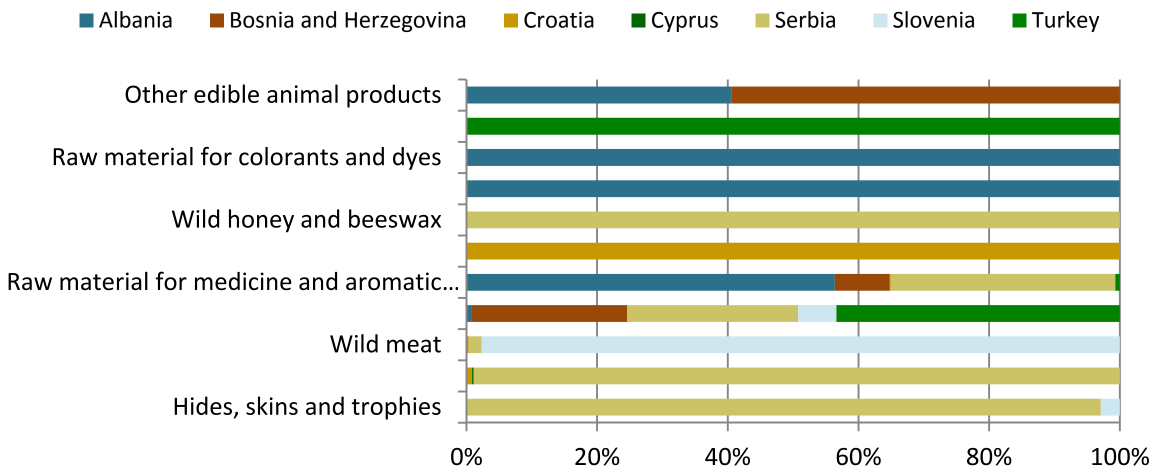


Figure 2.60. Percent of various categories of NWFPs provided by eastern countries, 2010
Source: FAO, 2010b.

Figure 2.61 shows the percentages of NWFP categories contributed by various southern Mediterranean countries. Morocco provided 60 percent (161 000 tonnes) of the total weight of NWFPs (270 000 tonnes). The category “other plants” accounted for 51 percent (138 000 tonnes) of all NWFPs produced by countries in the southern Mediterranean subregion. The category “raw material for medicine and aromatic plants” accounted for 22 percent of the total (58 600 tonnes).

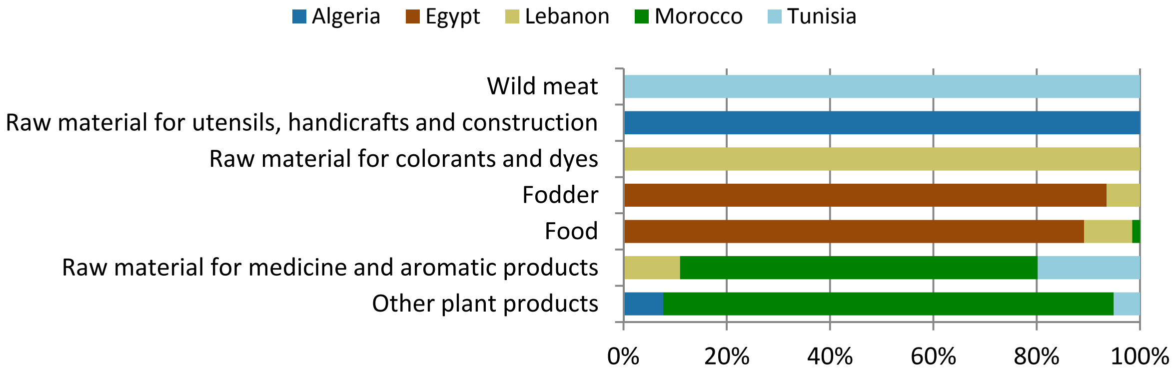


Figure 2.61. Percent of various categories of NWFPs provided by Southern Mediterranean countries, 2010
Source: FAO, 2010.

Conclusion

There is considerable potential in the Mediterranean region for NWFP harvesting to produce significant income and to generate rural employment and promote sustainable forest management. However, a lack of a legislative framework to regulate the harvesting and use of NWFPs is affecting the development of this subsector. A clear definition of NWFPs is needed to help countries to evaluate the importance of these products in local economies and to support new projects aimed at promoting the sustainable use of NWFPs.

Environmental services provided by Mediterranean forests

The role of forests in erosion control

Erosion risk. Erosion is the process by which soil is removed from the land surface by water, wind and gravity and deposited in another location. This natural process is hastened when human actions degrade vegetation cover by, for example, deforestation, intensive grazing and fire. The Mediterranean region was among the first regions worldwide to witness widespread human-induced erosion.

The most prominent forms of water erosion are sheet, rill and gully erosion. The risk of water erosion is the result of the multiplication of the following factors: rainfall and runoff; soil erodibility; slope length; slope steepness; vegetation cover and management; and conservation practices.

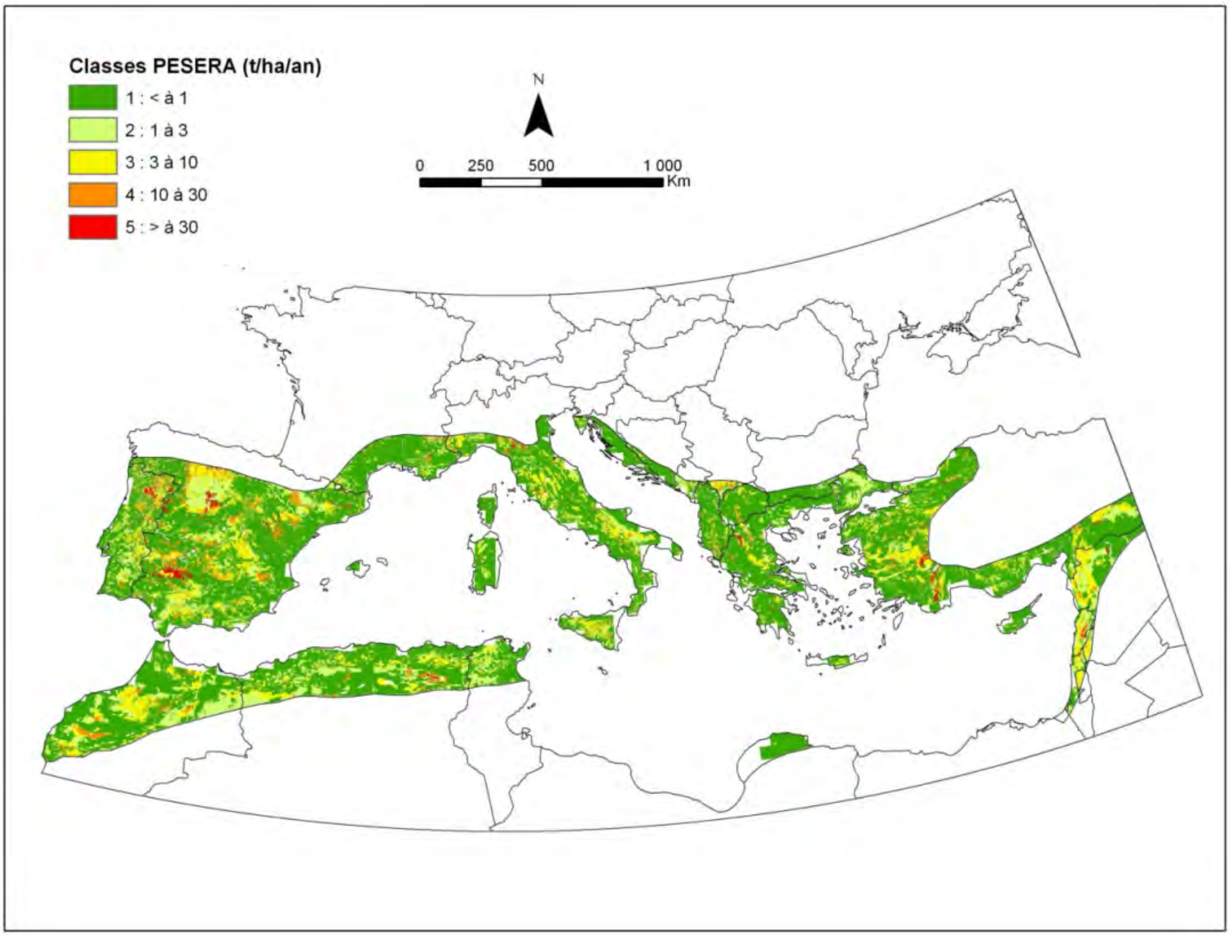


Figure 2.62. Erosion risk in the Mediterranean region, as assessed using the PESERA model
Source: Le Bissonnais et al., 2010.

The high risk of water erosion in some areas of the Mediterranean region (Figure 2.62) is determined by concentrated rainfall events, highly erosive geological material, steep slopes and sparse vegetation.

Wind erosion is less widespread than water erosion and occurs in specific zones, such as coastal dunes and transition zones to sand desert. For example, Turkey reported that 450 000 ha of land are affected by wind erosion, of which 40 000 ha are covered by sand dunes (AGM, 2010).

The role of forests in erosion control. Vegetation plays a crucial role in preventing water erosion by decreasing the effect of erosive forces and keeping the soil in place. A canopy cover of trees, shrubs or herbs significantly reduces the kinetic energy of raindrops (Albergel *et al.*, 2011). Less well studied is the effect of roots on topsoil resistance against concentrated flow erosion. A shallow but dense lateral-spreading roots system seems to be more effective for preventing water erosion by concentrated flow (De Baets *et al.*, 2009). Also important for the erosion resistance of forests is the typical occurrence of a leaf litter layer, which increases the hydraulic conductivity of the soil and decreases surface runoff.

Forest vegetation is very effective against wind erosion, and its effectiveness is determined by its lateral cover and the vegetation distribution (Okin 2008).

Forests are effective for preventing landslides when the shear plane of the slope is within reach of the roots. According to Reubens *et al.* (2007), a woody species with a large, deep and strong central part of the root system, comprising some rigid vertical roots penetrating deeply into the soil and anchoring into firm strata and a large number of finer roots numerously branching from the main lateral roots, would be most effective in increasing shallow slope stability. In cases where the shear plane of the slope is deeper than the regular rooting depth (*i.e.* > 3 m), trees may contribute to landsliding by favouring rain infiltration and hence the recharge of a water table within the hillslope (which lowers shear strength); and through the weight of trees that may contribute to the overloading of a potential shear plane (especially during strong winds).

From this it can be inferred that a low forest index (where a forest index is the percentage of land covered by forest) in the Mediterranean would translate into a high erosion incidence, an increase in the availability of blue water (see below on green and blue water services) and a decrease in blue water quality, and vice versa for a high forest index. Considering the increasing trend in forest index in most Mediterranean countries, a trend of decreasing sediment loss may be expected.

Forest fires increase risk of erosion. Forest fire leads to the destruction of forest biomass and a loss of capacity of ecosystems to regulate water, nutrient and sediment flows. Forests typically have erosion rates of less than 1 tonne of sediment per ha per year, while burnt areas can have erosion rates of more than 20 tonnes per ha per year and dirt roads of up to 100 tonnes per ha per year.

Sediment loss by erosion increases with the area annually burnt in the Mediterranean region. Considering the erosion factors, it can also be inferred that erosion risk increases with the dimension of burnt areas, with large areas being more prone to erosion. In the European-Mediterranean countries there was a decreasing trend in the total burnt area, and also in the average size of fires (Figure 2.63), which are probably the combined effect of fire prevention and fire fighting. It can be expected that this trend resulted in a decrease of soil erosion.

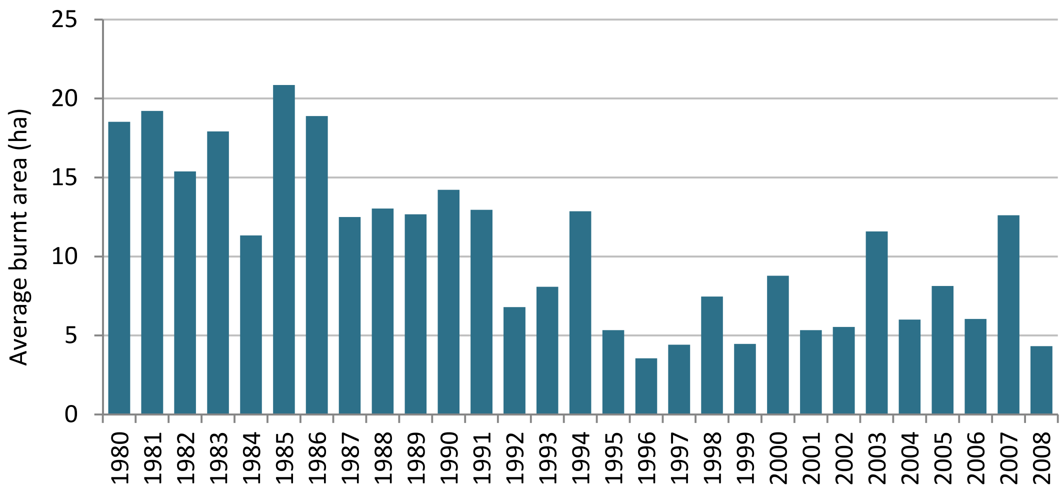


Figure 2.63. Trend of average area damaged by a single fire in the European Mediterranean countries
Source: Derived from JRC statistics on total burnt area and number of fires.

Forests and water services

Forests for green and blue water services. For a better understanding of the hydrological cycle it has become common to distinguish between green and blue water (Figure 2.64).

Blue water resources comprise the fraction of rainfall that reaches rivers and other surface waters, indirectly after percolation into the deeper aquifers or directly as surface runoff. Thus, the blue water flow feeding terrestrial water bodies such as rivers and lakes is composed of a base flow component and a surface runoff component. People around the Mediterranean strongly value the quantity and quality of blue water as it constitutes the main source of water for consumption, irrigation, hydropower and recreational activities.

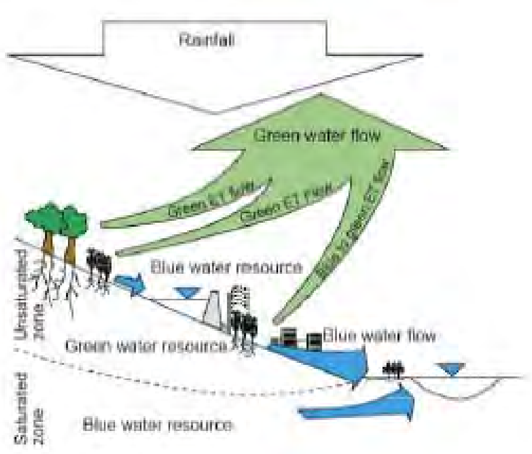


Figure 2.64. Green and blue water resources and flows
Source: Falkenmark and Rockstrøm, 2005.

Green water resources comprise the fraction of rainfall that infiltrates into the soils of terrestrial ecosystems and becomes available for uptake by plants. The evapotranspiration of terrestrial ecosystems is called the green water flow and is composed of transpiration and interception evaporation by vegetation and by evaporation from soils and terrestrial water bodies (Birot and Gracia, 2011).

Forest land use typically shows larger green water and smaller blue water fractions compared with urban or agricultural land use, which also means that afforestation would lead to more green water and deforestation to more blue water. Green water flows are often considered as a water loss because they lead to a lower supply of blue water for human use. But green water has important functions, including biomass production, erosion control, nutrient retention and many other ecosystem services (Birot and Vallejo, 2011). Recent research even shows important off-site effects of green water.

Both blue and green water flows are essential for sustainable catchment management in the Mediterranean region. There is a direct tradeoff between green and blue water use, and development in either direction (*e.g.* blue water maximization by impeding forest restoration or green water maximization by establishing fast-growing exotic tree plantations) may have negative impacts on the provision of integrated terrestrial/aquatic ecosystem services (Maes *et al.*, 2009).

Forests and water quality

In general, forests are the best land use for guaranteeing water quality, thanks to the relative naturalness of forest management (with no or minimal use of biocides and fertilizers and low wastewater release). As a consequence, many cities in the world, including in the Mediterranean region, obtain their drinking water from forested catchments and pay forest owners and managers to maintain and sustainably manage the forest cover. Sylvamed

(2012) provides a review of the management of water quality in Mediterranean forests, including a brief description of forest owner perceptions and management options for ensuring water quality in forests.

Protective forests in the Mediterranean

Table 2.19 shows the area of forests that are primarily designated for soil and water protection in Mediterranean countries.

Table 2.19. Forests designated for soil and water protection in Mediterranean countries, 2010

Country	Total forest area (1 000 ha)	% primarily designated for soil and water protection
Albania	776	17
Algeria	1 492	53
Bulgaria	3 927	12
Croatia	1 920	4
Cyprus	173	0
Egypt	70	49
France	15 954	2
Greece	3 903	0
Israel	154	15
Italy	9 149	20
Jordan	98	98
Lebanon	137	25
Libya	217	100
Montenegro	543	10
Morocco	5131	0
Palestine	9	
Portugal	3 456	7
Slovenia	1253	6
Spain	18 173	20
Syrian Arab Republic	491	0
Tunisia	1 006	41
Turkey	11 334	17

Source: FAO, 2010b.

As shown in Table 2.19, 20 percent of Italy's forests are formally designated for soil and water protection. However, it reported to FOREST EUROPE, UNECE and FAO (2011) that over 80 percent of its forests have (soil and water) protective functions and that the national policy goal is to achieve the hydro-geological protection of mountainsides in order to prevent landslides, erosion and similar hazards (Figure 2.65). For that reason, about 90 percent of forest land has been legally defined and cannot change use.

Figure 2.65. Plantation of *Pinus halepensis* in Jordan for protective purposes. ©FAO/Jean Louis Blanchez/FO-5301.

About 500 000 ha of forest in Italy are protected by regional laws and other provisions such as watershed management plans. In Spain, estimates of the proportion of the total forest designated for soil and water protection vary from 20 percent (FAO, 2010b) to 24 percent (FOREST EUROPE, UNECE and FAO, 2011). In Cyprus, Greece, Morocco and the Syrian Arab Republic, no forests are primarily designated for soil and water protection, and in France only 2 percent is so designated. This does not necessarily mean that soil and water conservation is considered an unimportant forest function in these countries (since forest of any designation can deliver these services). However, an advantage of specifically dedicated forests is the possibility of developing management plans focused on erosion control – which might include, for example, limiting the area of clearcuts and strict norms related to road building. Between 1990 and 2010, the area of protective forests increased from 15.2 million ha to 15.9 million ha in western Mediterranean Europe and from 2.1 million ha to 3.1 million ha in southeastern Europe including Turkey (FOREST EUROPE, UNECE and FAO, 2011).

Large programmes of forest restoration for soil and water conservation have been established in some countries; for example, Turkey is a world leader in erosion control. The Turkish programme for erosion control is coordinated by the General Directorate of Combating Desertification and Erosion. As of 2010, 810 731 ha of land had been subject to erosion control works, 1 453 492 ha of degraded forests had been rehabilitated, and 2 040 046 ha of new forest had been established (AGM, 2010).

Valuing protection functions. According to Willis et al. (2003), the value of protective and watershed services can be estimated in terms of:

- *replacement* (avoided) costs – *e.g.* the reduced cost to society where forests regulate runoff and hence lower flood risks and the need for flood prevention. For example, Daly-Hassen *et al.* (2012) showed that forests reduced sedimentation in the Siliana water reservoir in Tunisia by 12.9 m^3 per ha per year. Based on the cost of removing sedimentation from the reservoir it was estimated that forests saved 1.2 million Tunisian dinars per year (51.4 Tunisian dinars per ha of forest area per year).
- *Willingness to pay* – the extent to which individuals are willing to pay for marginal increases in security of supply or improved supply of services such as soil protection and water quality. For example, Mavsar and Riera (2007) estimated that, on average, residents in Spain would be willing to pay €3.90 for a 1-percent increase in the availability of drinking water in the country's Mediterranean region.

There are a number of difficulties in estimating benefits related to watershed protection. The relationships (*e.g.* between forest and water) and the impact of forests on watershed protection is not always clear (Whiteman, 2005). For example, forests are believed to improve water quality, but this is only true under certain circumstances. There are examples of where forestry activities have led to a decline in water quality (*e.g.* through soil disturbance due to harvesting and afforestation). Moreover, there is still no scientific consensus on how forests influence water quantity: some valuation studies consider that forest provide positive benefits related to water quantity (*e.g.* Mavsar and Riera, 2007), while some other estimate negative values (*e.g.* Merlo and Croitoru, 2005). The effects of forests on large catchments are especially difficult to assess. Another issue relates to the methodologies for estimating benefits: the avoided costs method, for example, might capture only part of the full value of the services provided.

Carbon services

Carbon stocks and fluxes in Mediterranean forests. Forest ecosystems play a key role in the global carbon cycle and climate regulation, since carbon is exchanged naturally and continuously between forests, soils and the atmosphere through photosynthesis, respiration, decomposition and combustion. Of all land-use types, forests have the largest carbon storage capacity. Carbon is stored both in aboveground (wood, leaves and litter) and belowground (root) biomass, as well as in soils (*e.g.* in the form of soil organic carbon) (Bolin *et al.*, 2000; IPCC, 2007a).

Globally, forests store about 77 percent of the carbon contained in the aboveground vegetation biomass and 42 percent of the top 1 m of soil carbon (Bolin *et al.*, 2000). The carbon storage capacity depends on multiple factors, such as forest surface area, tree volume, age, structure, vegetation diversity, composition and interactions, and particularly on tree and understorey vegetation growth, which is tightly controlled by water, nutrient and light availability, temperature, pests, diseases, fire and management (Dixon *et al.*, 1993; FAO, 2011; Vayreda *et al.*, 2012).

Forests act as carbon sinks, especially when young or regenerating after disturbances, or in response to management interventions, and may therefore contribute to climate change mitigation, removing carbon dioxide from the atmosphere and storing carbon. Nonetheless, they can also act as carbon sources if disturbed, poorly managed, overexploited or burnt (Ding *et al.*, 2011). The carbon balance of forests can be quantified by evaluating carbon stocks and fluxes, for example by using the eddy covariance technique and modelling approaches, together with field sampling and remote sensing (Gracia *et al.*, 2001; Garbulsky *et al.*, 2008; Garcia *et al.*, 2010).

Mediterranean forests are estimated to sequester 0.01–1.08 tonnes of carbon per ha annually (Merlo and Croitoru, 2005); that is, between 0.8 and 90 million tonnes of carbon per year. They represent therefore a significant carbon sink, in addition to performing other valuable ecosystem services such as water and climate regulation, the provision of wood and non-wood products and amenity, and biodiversity conservation. According to FAO (2011), forest cover is expanding in the north of the Mediterranean region (by 556 000 ha per year between 2000 and 2005), while it is stable or slightly increasing in the SEMCs (increasing overall in that subregion by 120 000 ha per year between 2000 and 2005, despite limited forest cover and forestation potential in many of those countries).

According to an evaluation made in 2005 (Ding *et al.*, 2011), the economic value of carbon storage in Mediterranean forests (latitude 35–45° N) ranges between US$37 billion and US$63 billion, *i.e.* 13 percent of the forests total economic value, for the IPCC climate change scenarios A1 and B2, respectively, with 2050 as the horizon. This economic value is smaller than that of forests from central–northern Europe (latitude 45–55° N; US$117 billion to US$190 billion), but higher than that of forests in northern Europe (latitude 55–65° N; US$11 billion to US$23 billion) and Scandinavian Europe (latitude 65–71° N; US$32 billion to US$35 billion).

Impacts of climate change on the carbon balance in Mediterranean forests. Climate change might influence forest expansion positively or negatively by increasing or inhibiting tree growth and aboveground and belowground carbon storage. Carbon dioxide enrichment might stimulate tree growth, while a rise in temperature and more severe and repeated droughts might cause higher soil carbon losses and tree mortality and dieback. In 2003, for example, western and central Europe experienced an exceptionally dry and hot summer that triggered a considerable increase in carbon losses to the atmosphere (Jones and Cox, 2005).

In the Mediterranean, most forests consist of sclerophyllous and deciduous species that are relatively well adapted to soil water deficits, but the expected rise in the frequency and strength of those deficits is likely to cause changes in forest composition (IPCC, 2001) and thus in carbon stocks. Warming is likely to favour the expansion of some thermophilous tree species in areas where water availability is sufficient, which might result in a northward shift in their distribution range, for example for *Quercus pyrenaica* (IPCC, 2001) and *Olea europea* (Salvati *et al.*, 2013), and in the subsequent geographical displacement of carbon stocks.

Forest management and use of forest products as a tool to improve carbon storage. The carbon sink function of Mediterranean forests and their multifunctionality are of such importance that the forests should be evaluated as part of land-use planning and priority given to implementing rational, cost-effective, socially acceptable and adaptable forest conservation and management strategies. Indeed, forest cover and volume, and subsequently the carbon stored in those ecosystems, fluctuates over time. On the one hand, carbon stocks can be negatively affected by deforestation (*e.g.* land-use conversion and urban development), fire and poor management, but on the other hand they can be enlarged by favourable economic contexts and policies promoting, for example, sustainable forest management, the reforestation of abandoned agricultural land, the establishment of commercial plantations and fire prevention and control.

Numerous adaptive forest and landscape management strategies and interventions, which may require changes in forestry guidelines and visions, have been recommended for the sustainable use of multifunctional Mediterranean forests to enhance long-term carbon storage and further mitigate climate change (see, for example, Regato, 2008; Serrada, 2011; Vericat *et al.*, 2012). They include:

- the promotion of forestation and reforestation activities (using monospecific or diversified stands) (Figure 2.66);
- the restoration of degraded soils; encroachment management;
- site-specific silvicultural practices such as selective logging, dead wood removal and thinning to reduce stand density (Figure 2.67), decrease competition for water, activate biomass production, enhance resistance and resilience to disturbances (*e.g.* fire and pests) and increase sexual regeneration;
- practices at the landscape and stand scale to reduce forest fire intensity, propagation and damage and to improve ecosystem resilience and recovery; post-fire restoration activities;
- the promotion of better-adapted trees (*e.g.* that are tolerant to drought and pests) and modifications in tree species composition (*e.g.* more diversified and resilient stands, multipurpose trees);
- the restoration and conservation of biotic communities, specifically dispersal vectors (*e.g.* birds and mammals);
- the improvement of soil management practices to increase water-storage capacity and hinder erosion and carbon loss (*e.g.* sustainable grazing, low disturbance during wood extraction and the reduced use of chemicals);
- the use of wood for long-term purposes (*e.g.* building construction, furniture and handicrafts).

Figure 2.66. Nursery of Stone pine (*Pinus pinea*) for reforestation and afforestation purposes.
© Lorenza Colletti

If wood is used for construction, storage is ensured in the long term – that is, over several decades – but when trees are cut down and used as fuel or for paper production, or when they are burnt, part of the stored carbon is released to the atmosphere and soil, contributing to climate change. Forest management policies and strategies must therefore aim to prolong the storage capacity of both the forests and their products.

Long-term wood products can be used as energy sources at the end of their life spans, recycled and reused, and this process can create jobs all along the production chain, with positive impacts on local economies. Several life-cycle studies have shown that wood products generate much lower greenhouse gas emissions than comparable products: for example, 1–2 times fewer emissions than cement, 5–6 times fewer emissions than steel and 4–5 times fewer emissions than aluminium. Moreover, wood has much better thermal efficiency: 15 times better than concrete, 400 times better than steel and 1 770 times better than aluminium. The use of 1 m^3 of wood as a substitute for other construction products can contribute to a reduction of 1.1 tonnes of carbon dioxide emissions because of this thermal efficiency, and up to 2 tonnes when also accounting for the carbon stored in the wood itself (Beyer *et al.*, 2011).

Figure 2.67. Example of thinning in Urbion, Spain.
©Pilar Valbuena.

Effect of fires on the carbon balance of Mediterranean forests. Forest fires burn hundreds of hectares of forests and OWLs in the Mediterranean region each year, resulting in the release of aboveground and belowground carbon stored in the vegetation and soil. Climate change scenarios foresee an increase in the intensity and frequency of high-intensity fires in the near future (IPCC, 2007a), which will trigger higher carbon losses and severely diminish the recovery capacity of the vegetation in burnt areas due to both higher fire recurrence and progressive soil degradation and loss. Therefore, in order to preserve carbon stores and the carbon sequestration potential of Mediterranean forests, it is essential to actively manage forests to reduce the risk of intense wildfire, for example by thinning to reduce tree density, using prescribed fires to control fuel availability, and creating firebreaks and discontinuities in the landscapes to slow fire progression and attenuate their intensity (Kashian, 2006; Vericat *et al.*, 2012). Such measures can increase forest resilience, accelerate recovery and consequently stimulate carbon sequestration capacity.

Payments for carbon sequestration services. Several mechanisms and tools exist or are being developed to encourage greenhouse gas emission reductions and carbon sequestration and to meet Kyoto Protocol targets; they include joint implementation and the Clean Development Mechanism (UNFCCC, 2013), the EU Emissions Trading Scheme (EU Commission, 2013), and the proposed scheme to reduce emissions from deforestation and forest degradation in developing countries (REDD+) (UN-REDD, 2013). Global carbon markets are expanding rapidly but many challenges remain – including on financing, monitoring and the double-counting of credits. However, carbon sequestration by forests represents only a small part of current carbon markets, and in most schemes forest carbon receives little attention. Voluntary markets and public payments hold promise for the forest sector, since buyers are keener to use carbon payments to restore degraded lands and encourage agroforestry on a large scale. Payments contemplated in the framework of REDD+ for avoided deforestation and forest degradation, carbon stock enhancement and sustainable management, are also of growing interest and could finance significant greenhouse gas emissions reductions.

In addition, the use of forest biomass for heating, cooking and electricity generation is another way of reducing greenhouse gas emissions by substituting for the use of fossil fuels, for which the carbon footprint is much higher – as long as the forest biomass is derived from sustainably managed forests and efficient stoves, boilers and cogeneration systems (*e.g.* wood gasification for generation of electricity and heat) are used. In some cases, these emissions reductions are eligible for carbon credits, making such approaches more economically attractive.

Conclusion. The sustainable management of Mediterranean forests is essential for adapting to and mitigating climate change. It requires strategies and actions that enhance ecosystem services in general and carbon sequestration in particular and that promote the use of wood products for long-term carbon storage and the generation of renewable energy. There is clear evidence that the cost of investing in prevention actions to reduce greenhouse gas emissions is far smaller than the cost of the expected impacts of climate change (Stern, 2007).

Forest management must be at the heart of climate change mitigation and adaptation strategies at the regional, national and international levels. European forests in general, and Mediterranean forests in particular, have been managed intensively for centuries and shaped by human activities, and a range of management options and forestry practices, supported by empirical and scientific evidence, is available for use in adapting to climate change (Alcamo, 2007; FAO, 2011). Nevertheless, mitigation measures in the forest sector must be supported by adequate incentives and accompanied by measures to decrease greenhouse gas emissions in other sectors of the economy, such as the industry, transport, agricultural and energy sectors.

Mediterranean forests as providers of social ecosystem services

The relationship between people and forests is continually evolving. The socio-economic changes of recent decades triggered by urbanization and increases in living standards have increased the importance of the ecological, recreational and landscape functions (*i.e.* ecosystem services) of Mediterranean forests (Palahi *et al.*, 2008). In contrast, the benefits people obtain from forest extraction (*e.g.* wood, food and fodder) are becoming less significant. Forest ecosystems provide a wide range of opportunities for leisure, mental development and spiritual enrichment (DeGroot *et al.*, 2002). Social and cultural services provided by ecosystems include recreation and ecotourism; cultural heritage values and cultural diversity; spiritual and religious values; aesthetic values; educational values and knowledge systems; inspiration; social relations; and sense of place (Alcamo *et al.*, 2003).

These types of social services are tightly connected to people's values and behaviours, as well as to the social, economic and political organization of a society. Thus, perceptions and preferences for social services are more likely to differ among individuals and communities than are perceptions of the importance of (for example) wood or food production.

Forest providing social ecosystem services in the Mediterranean

The share of forests designated to provide social functions (as reported in FAO, 2010b) is used here as a proxy for assessing the importance of Mediterranean forests as providers of social ecosystem services (Table 2.20).

Table 2.20. Area of forests primarily designated for social functions and multiple use in Mediterranean countries

Country/area	Total forest area (1 000 ha)*	Percentage primarily designated for social functions*	Percentage primarily designated for multiple use*	Annual visits per ha of forest and other wooded lands**
Albania	776	0	0	..
Algeria	1 492	..	0	..
Bulgaria	3 927	6	8	..
Croatia	1 920	2	9	0.8
Cyprus	173	8	28	1.7
Egypt	70	0	46	..
France	15 954	..	22	28.7
Greece	3 903	0	0	..
Israel	154	3	64	..
Italy	9 149	..	0	16.8
Jordan	98	1	0	..
Lebanon	137	0	66	..
Libya	217	0	0	..
Montenegro	543	0	0	..
Morocco	5 131	0	67	..
Palestine	9	..	..	..
Portugal	3 456	0	30	..
Slovenia	1 253	6	11	..
Spain	18 173	2	46	..
Syrian Arab Republic	491	0	100	..
Tunisia	1 006	0	32	..
Turkey	11 334	..	6	..

Sources: *FAO, 2010b; **FOREST EUROPE, UNECE and FAO, 2011.

Only seven countries in the Mediterranean region have forests designated primarily for social functions. In those countries, the share of such forests varies between 1 and 8 percent of the total forest area. Some countries (*e.g.* Lebanon, Morocco and the Syrian Arab Republic) reported that more than half of their forest estate is managed for multiple uses.

Social ecosystem services can be provided by almost any type of forest (and regardless of their designated function), depending on people's perceptions. FOREST EUROPE, UNECE and FAO (2011) report the share of forests accessible for forest recreation. In southwestern Europe, 78 percent of forests and OWLs is available for recreation, while in southeastern Europe this share is 93 percent. Four Mediterranean countries reported the average number of visits per ha of forest and OWLs (Table 2.20), which varied between 0.8 and 28.7.

Data on social ecosystem services provided by forests is scarce for most countries and do not reflect the importance of forests in this regard. In most cases the data are limited to certain areas, such as national parks. For example, Spain's six national parks in the Mediterranean region had a total of 1.6 million visitors in 2008, an increase of 40 percent over the previous decade (Mavsar and Varela, 2010).

Valuing social ecosystem services

Studies that valued forest recreation have used both revealed preference methods (*e.g.* the travel cost method) and stated preference methods (*e.g.* contingent valuation). The travel cost method takes the cost of practising recreation as a proxy for the value of a recreational site. Contingent valuation and choice modelling estimate the value of a recreational service by asking users the extent to which they are willingness to pay to obtain or maintain a form of recreation. For example:

- *Payments to have access to forests or specific areas (e.g. national parks) for recreational activities*. In a study in Tunisia, Daly-Hassen *et al.* (2010) estimated the willingness of Tunisians to pay to have access for recreation to newly afforested areas. They found that, on average, a Tunisian resident would be willing to pay 6.2 Tunisian dinars per year to have access to the afforested areas.
- *Payments for specific recreation activities*. Brey *et al.* (2007) applied a choice modelling approach to estimate the willingness to pay to support an afforestation programme in Catalonia in northeastern Spain, which (among other things) would result in improved recreational possibilities. They found, that on average, individuals would be willing to pay €6.3 per year to be allowed to picnic in the new forests and €12.8 per year to be allowed to pick mushrooms.
- *Payment for improved or maintained forest management or improved recreation facilities*. In Corsica, a choice experiment was conducted to determine the willingness to pay for enhanced forest fire prevention, the protection of fauna and flora, and the improvement of recreational facilities in the Bonifatu (Bonnieux *et al.*, 2006). The highest willingness to pay was estimated for forest fire prevention and fauna and flora protection programmes, but there was a negative willingness to pay to improve recreational facilities.

There remain, however, a number of issues associated with valuing social ecosystem services, such as:

- *Framing the relevant population.* It is not always clear whose values should be included in a valuation study. Usually only users are considered, but some studies (*e.g.* Huhtala and Pouta, 2008) indicate that nonusers may also gain considerable benefits from public recreation services.
- *Estimating the value of different recreation possibilities.* The bulk of current research values forest recreation either in a generic sense or as a single attribute. Few studies explore the heterogeneity of forest recreation benefits obtained by alternative uses and different users.
- *Assessment techniques.* The methods used to value recreation have advantages and disadvantages. For example, the revealed preference approach has the advantage that values are grounded on actual behaviour, but it is unable to value resource provision beyond current levels. Stated preference approaches overcome this limitation, enabling valuations to go beyond existing levels of provision, but they depend strongly on survey design and may be subject to a wide range of biases (*e.g.* people are not used to placing values on an environmental good or service, and respondents might rather be expressing their feelings about the scenario or the valuation exercise itself) (Christie *et al.*, 2007).

2.4 Urban and peri-urban forestry in the Mediterranean region

"Mediterraneans feel closer to their cities than to their states or nations; indeed, cities are their states and nations and more," wrote Matvejevic in 1999. Today, most Mediterranean cities suffer for a lack of green space. Urbanization and the associated process of land consumption continue to increase. Recent decades have been characterized by changes in climate, deep modifications to lifestyles, and heavy landscape alteration, posing major challenges for urban decision-makers. New approaches can help in facing these challenges: high-tech "smart cities" are pursuing new models and tools of urban governance. Nevertheless, planting trees and designing and managing urban forests or parks (Figure 2.68) are still effective ways – in the Mediterranean and elsewhere – to advance quality of life, give lifeblood to city landscapes, build green economies and mitigate the effects of climate change.

Figure 2.68. ''Parc de l'Esplanade'' in Montpellier, France
©Gilles Milles

In recent decades, urban and peri-urban forestry[5] (UPF) has emerged as an integrative, multidisciplinary approach to the planning, design and management of forest and tree resources in and around urban areas. The UPF approach addresses economic, social and environmental challenges by providing multiple services and benefits that are highly valuable for the quality of life of urban dwellers. Potential benefits of urban and peri-urban forests and trees include climate-change mitigation and adaptation in urban areas, supplemental food supply, increased health, well-being, jobs and income, biodiversity conservation, watershed management, and disaster risk prevention. A coherent investment by communities and governments in the protection and restoration of forests and trees can make a real contribution to creating a healthy environment, including by helping to reduce poverty and malnutrition. It requires partnerships and alliances based on multistakeholder approaches between local and decentralized authorities, mayors, civil communities, practitioners and researchers in various disciplines.

Here, UPF is treated as the management of urban and peri-urban forests and trees in the Mediterranean region. Terms such as "urban and peri-urban forestry and greening" and "urban and peri-urban forests" are found in the literature and tend to consider all type of tree systems together; "greening" includes shrubs and herbaceous plants. However, no

[5] UPF: The management of trees for their contribution to the physiological, sociological and economic well-being of urban society. UPF deals with groups of trees and individual trees where people live. It is multifaceted because urban areas include a great variety of habitats (streets, parks, derelict corners, etc.) where trees bestow a great variety of benefits and problems (Carter, 1995, after Grey and Deneke, 1978).

single definition has been agreed worldwide for these terms. Generally, the term "urban forests" is used to represent urban and peri-urban forests and trees, comprising all trees in woodlands, gardens, parks, forests, natural green spaces, agroforestry systems, orchards and alignments, in and around cities. Urban forests include both public and private lands and the term UPF takes into account broader landscape approaches (such as watershed management) and issues such as soil and biodiversity conservation. However for the purposes of this report, and given that the term "forest" is usually legally defined in local and national legal contexts as well in international fora (*e.g.* FAO and the UNFF), "forest" is used in accordance with local definitions. When referring to all tree systems in and around urban areas the paper will use the expression "urban and peri-urban forests and tree systems".

The faces of urbanization

The spatial distribution of a population is a key element in understanding the use and consumption of resources in a given area. The Mediterranean region is one of the world's largest urbanized areas (and was probably the largest until the sixteenth century) and has one of the highest urban footprint on the planet (Bourse, 2012). According to Plan Bleu's most recent demographic forecasts (Plan Bleu, 2010), 507 million inhabitants live in the Mediterranean region (in 2010), which is 7.7 percent of the global population. The total is projected to reach 570 million by 2025, with most growth (95 percent) concentrated in the SEMCs. Despite the high rate of urban population growth and contrary to other highly populated parts of the world, urbanization in the Mediterranean region occurs mainly in a large number of small-to-medium cities, rather than in megacities. In 2010, of the world's 100 largest urban agglomerations only seven were in Mediterranean countries, and only four of those could be considered to fully express the character, problems and opportunities of a Mediterranean city (Demographia World Urban Areas, 2012).[6] One of the peculiarities of the region is the high rate of urbanization of coastal areas, usually linked to tourism. The proportion of the population living in coastal areas increased from 63 percent in 1970 to 70 percent in 2000 and is expected to reach 76.6 percent by 2025. An estimated 40 percent of the Mediterranean region's 20 000 km of coast is occupied by urban settlements. According to the Mediterranean Action Plan (UNEP/MAP, 2012), this percentage is expected to increase to 50 percent by 2025.

Driving forces and environmental consequences of urbanization

In addition to implying an increase in the number and density of people, urbanization concerns the occupation of land and the use of energy, water, food, woodfuel and forest and agricultural lands. It affects the availability of habitats and their fragmentation, modification and isolation, as well as the permeability of soils and pedogenetic processes. Population growth, including immigration and tourism, has contributed to an increase in land occupation by "grey infrastructure" (*e.g.* roads and buildings). There is urban poverty in cities of the south Mediterranean and also those in the north. For example, Naples, in Italy, in one of the Mediterranean's most degraded cities in environmental, social and

[6] The four are: Cairo and Alexandria, Egypt, ranked 18th and 74th, respectively; Istanbul, Turkey, ranked 19th; and Barcelona, Spain, ranked 53rd.

economic terms; furthermore, a study by UN-HABITAT (2003) found that 25–35 percent of Cairo's population lives in slums in and around urban areas.

The consequences of urbanization pressures include increases in landscape and habitat fragmentation, fire risk, land degradation and desertification, food insecurity and human disease. Landscape and habitat fragmentation goes together with changes in landscape pattern, the latter tending towards simplification and a decrease of biodiversity. Both are the end result of socio-economic change in which rural and forestry work is replaced by an expansion of industry and especially the services and tertiary sectors. Wildfire events have become more frequent and closer to cities. In all urbanized areas in the Mediterranean region, land-use modification and the consequent regrowth of forest and scrublands has led (especially in southern Europe) to new spatial configurations called "wildland–urban interfaces"[7], which are vulnerable fringes to be protected or evacuated in case of fire. In the Mediterranean region, and particularly in coastal zones, urbanization can cause land degradation and desertification. This is linked to the demand for food and energy by urban people: in fact, although the impact of wood demand for energy and construction was very significant in the past and less in the present, the impact of food consumption is still highly problematic, at least in southern Mediterranean countries. Finally, the city can have either positive or negative effects on human health and well-being. It provides economies of scale in the provision of services, thereby promoting a general improvement in health control. But it can increase the potential recurrence of communicable diseases; produce large volumes of waste that need to be treated; lead to high concentrations of pollutants in water, soils and air; increase the frequency of extreme environmental events; and induce sedentary lifestyles that, associated with the often high stress levels in cities, can have devastating consequences for mental and physical health.

Mediterranean UPF institutional framework

Experience in the management of natural resources, trees and forests related to the urban experience dates back almost two millennia in the Mediterranean. Nevertheless, during the twentieth century (especially from the late 1940s), little attention has been given to the management of urban and peri-urban forests and tree systems. The pan European programme COST Action E12 (1998–2002) was the first multinational framework in which delegates of various Mediterranean countries began to discuss and use the term urban forest. Konijnendijk *et al.* (2005) introduced a first reference framework in which to place the diversity of terms referring to urban forests in Europe.[8] Despite this, the term UPF is still not widely used in the region, especially in the non-European Mediterranean countries. The diversity of cultures, languages, societies, histories and policies in the Mediterranean region suggests that it will be challenging to find a common definition of urban forest and to amplify the concept to include peri-urban woodlands and open spaces. Moreover, on the one hand there are a large number of studies on UPF in Mediterranean countries, and on the other there is a reluctance to adopt UPF as a scientific discipline and as a strategic

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[7] Wildland–urban interface: areas where houses meet or intermingle with undeveloped wildland vegetation, and where increased human influence and land-use conversion are changing natural resource goods, services and management.

8 According to Konijnendijk (2005), urban forests are all individual trees, tree groups, small woods (*e.g.*in parks), and urban and periurban woodlands.

factor in the future development of cities. To date there is no up-to-date regional overview of the experiences gained and expertise acquired; no action plans or national strategies for meeting the long-term challenges of cities that take into account the potential contributions of forests and trees; and no specialized UPF network focusing on the Mediterranean region.

In its "Key action 12: explore the potential of urban and peri-urban forests", the European Union Forest Action Plan (CEC, 2006) specifies two actions: review and integrate methodologies for evaluating the social and human impacts of urban and peri-urban forests and tree systems in order to establish appropriate long-term indicators and robust frameworks to guide future investment and management; and explore structures to engage local communities and non-traditional stakeholders in planning, creating, managing and using urban and peri-urban forests and tree systems. At the international level, UN-Habitat (Nairobi), the United Cities and Local Government (Barcelona), the World Association of Metropolis (Barcelona) and Sustainable Cities (Bonn) are key international institutions dealing with urban and urbanization issues. Increasingly such institutions are integrating food and nutrition security in strategic planning, highlighting the role of trees and forests in providing food to cities. An international urban forestry agenda promoting cooperation between countries is also in place: since 1998, the European Forum on Urban Forestry has developed an extensive network across most European countries. The International Union of Forest Research Organizations (IUFRO) has had a working group on urban and peri-urban forestry since the 1980s, which has increased scientific collaboration on the topic globally. In Africa, the triennial "Africities Summit", led by the United Cities and Local Government of Africa, offers international organizations and companies the opportunity to interact with African government leaders on a continental scale. The "African Chart of civil participation" was adopted within the framework of the sixth Africities Summit (Dakar, 4–8 December 2012).

In FAO, the coordination of urban issues is facilitated by the FAO Food for the Cities Initiative. The FAO Forestry Department has a specific programme on UPF, with activities at the global, regional and national levels; among other things, it published a series of case studies on Mediterranean cities (in Cyprus, Egypt, Jordan, Lebanon, the Syrian Arab Republic and Turkey) (El Lakany *et al.*, 1999). In 2006, an outlook study to 2020 on urban and peri-urban forestry and greening in West and Central Asia contained information on eight countries in the Mediterranean region. The European Forum on Urban Forestry is strengthening its network in the Mediterranean region, including through workshops. FAO published a thematic report on the assessment of trees outside forests in January 2013 (de Foresta *et al.*, 2013). Finally, a Mediterranean Working Group on Urban and Peri-Urban Forestry was launched at the 21st session of the Committee on Mediterranean Forestry Questions, *Silva Mediterranea*, in 2012.

The Mediterranean Strategy for Sustainable Development, prepared as part of the Mediterranean Action Plan, includes an objective to "improve the quality of urban life by expanding green areas and by reducing negative environmental factors (air pollution and waste generation), as well as social disparities and inequalities in access to services", particularly in SEMC cities. Despite this, no indicators have been developed for the effective evaluation of the urban environment in terms of green infrastructure and open spaces available to citizens. Existing indicators on the sustainability of the urban environment pertain only to questions of waste generation and air quality and pollution.

Four Mediterranean UPF approaches

There are four main approaches to UPF in the Mediterranean region. One, taken by northeastern Mediterranean countries such as Slovenia, Croatia, Romania and Turkey and, to a minor extent, Israel and Morocco, is linked to the planning, design and management of woodlands in and around towns, in line with the central–northern European approach. The strong forestry and silvicolture tradition in these countries ensures that urban forestry is considered part of the wider forestry technical environment, and forest services or other central governmental institutions are responsible for the planning, design and management of urban and peri-urban forests and tree systems.

A second approach, which focuses on urban parks and gardens (Figure 2.69), does not consider urban forests in a comprehensive way. The countries where this approach is strong (Algeria, Bulgaria, Cyprus, France, Lebanon, Malta, Spain and Tunisia and, to a minor extent, Egypt, Greece and Morocco) generally consider urban forests only as one of the possible type of urban and peri-urban green open spaces where you can find tree. According to this approach, UPF is less management-oriented and concerns more territorial and forest planning than urban planning. Municipalities or other local institutions are the owners of and are responsible for public green spaces, and the central state may provide technical assistance.

Figure 2.69. '' Parc Arthur Rimbaud'' in Montpellier, France
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In a third approach, urban and peri-urban forests and tree systems are key elements in an ecological network of protected areas providing a multifunctional set of benefits, including those related to biodiversity, climate change adaptation, carbon sequestration and environmental quality. The European Mediterranean countries of Croatia, France, Greece, Italy, Portugal, Slovenia and Spain are very familiar with this approach. Municipalities or other local institutions are the owners of and are responsible for public parks and gardens, and the institutions of the central state may provide technical assistance.

A fourth approach, which could be called “UPF as an integrated approach”, involves the wide-ranging application of UPF techniques and seeks integration at multiple levels, from individual or street trees to cultural landscapes. In this sense, UPF has an open and profitable dialogue with related disciplines, particularly landscape ecology, landscape architecture and urban and ornamental arboriculture. Countries in which this approach is pursued are France, Italy and Portugal and, to some extent, Croatia, Greece, Slovenia and Turkey.

Quantitative data on urban and peri-urban forests in the Mediterranean are generally very poor. On the basis of European Environment Agency data, Fuller and Gaston (2009) produced a map of green spaces in European countries (Figure 2.70) and found that the area of green space per person (the “per capita green space provision”) varied significantly. The lowest values were found in the south and east and the highest in the north and northwest. For example, the green space provision in Cádiz, Fuenlabrada and Almería in Spain and Reggio Calabria in Italy was 3–4 m^2 per person, whereas it was more than 300 m^2 in Liège, Belgium, and Oulu, Finland. In Italy, Corona *et al.* (2011) used national surveys to calculate the total number and surface area of national urban and peri-urban forests and tree systems and their average size, availability and macro species composition (conifer or broadleaved) (Table 2.21).

However, while the World Health Organization has set minimum standards for green space per inhabitant, there is no official definition of “green space” itself, and as the meaning of the term changes significantly depending on local context and institutional framework, the interpretation of the data is problematic.

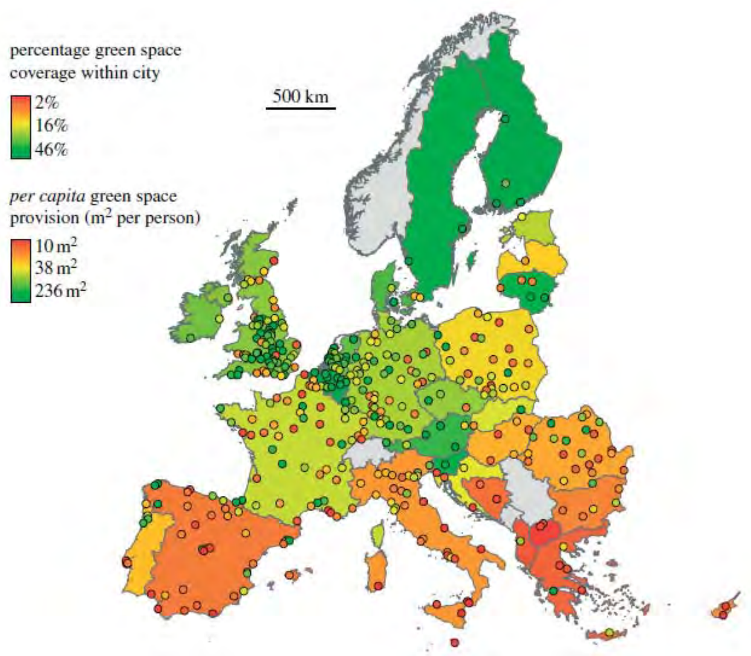

Figure 2.70. Urban green space coverage in Europe. Points representing cities are coloured according to proportional coverage by urban green space within the city. Country polygons are coloured according to per capita green space provision for its urban inhabitants.
Note: Data unavailable for shaded countries grey
Source: Fuller and Gaston, 2009.

Table 2.21. Data concerning Urban Forests according to the National Forest and Carbon Inventory of Italy

Indicator		Size	Unit
Total number of urban forest*		19 806	n
Total surface of urban forest*		43 000	ha
Average size of urban forest		2.2	ha
Availability of UF per capita		7	m^2
Tree species	Conifers	58	%
	Broadleaves	42	%

Note: *= *sensu* FAO, 2010b.
Source: Corona *et al.*, 2011

A survey of 75 urban forests in major cities in Turkey reported an average size of 377 hectares with a very wide range (from 1 hectare to more than 11 000 hectares). The survey applied a simple equation to estimate the carbon stored in those forests, which was more than 42 000 tonnes. In France, data from the National Forest Inventory (IFN) and a population census were used to calculate the rate of forests influenced by urban agglomeration (*i.e.* was subject to increased disturbance, especially to wildlife, and was also providing additional ecological and social services). The survey found that a significant part (21 percent) of the urban area was covered by forests and there was about 200 m^2 of forest per inhabitant (Inventaire Forestier National, 2010). Few data are available for other Mediterranean countries, especially in the southeast of region. The *Guide of the Urban and peri-urban Forests* of Morocco (Haut Commissariat aux Eaux et Forêts et à la Lutte Contre la Désertification, 2010) reported an area of 2.5 m^2 of green space per inhabitant in Moroccan cities. This guide defined urban forest as a “forest inside the urban texture”, and peri-urban forest as a “forest area influenced by an urban context” (according to a range of requested services, especially recreation and tourism) located less than 30 km from the urban area.

Strategic domains

The state of Mediterranean UPF and the benefits arising from the good management of urban and peri-urban forests and tree systems in urban and peri-urban areas can be synthesized in the following 12 strategic domains, with examples.

1. Combating desertification and mitigating climate change. The Moroccan Strategy on Urban and Peri-urban Forests and its action plan favours the planting of trees to help combat desertification. Optimizing the use of water in Mediterranean urban parks is a recurrent issue in UPF in Spanish-speaking countries. Approaches such as xeroscaping and xerogardening are helping to reduce water consumption in private gardens in urban development sites.

2. Helping alleviate poverty and sustain food and woodfuel production. Forest management and planning in the Syrian Arab Republic takes into account the contribution of forests and tree systems in food security and national income. It also involves designing

and managing trees outside forests and forests in and around cities, giving rise to a dense net of agroforestry systems and public and home gardens.

3. Producing economic benefits and contributing to employment. The Municipality of Stara Zagora, Bulgaria, invested in the adaptive and participatory management of urban parks (particularly the main park, Ayazamo) and green squares to attract people for business and to increase employment. Stara Zagora, also known as "the city of lime trees", is one of the richest cities in Bulgaria, thanks to the large number of business activities it has attracted.

4. Offering healthy environments for sport, recreation, art, education and culture. Urban forests are excellent places for hosting sporting, recreational and leisure activities. They are also amenable to artistic and cultural pursuits, and provide opportunities for formal and informal nature education. Another demonstration of the direct benefits urban forests is that, in some countries, insurance premiums decrease with increasing proximity to parks. The WHO/Europe recommended, in 2006, a series of actions oriented to promote physical activities to combat the increasing incidence of non communicable diseases in the contemporary societies. The "solid fact series" are addressed mainly to decision makers. A fundamental part of the recommendations concerns the challenge of planning and designing parks and urban forest as key-tools to combat the diseases derived from poor physical outdoor activities. Particular emphasis was dedicated to Mediterranean cities. Among the others, the case of Kadiköy, Turkey, where exercise equipment and walkways built at local parks and urban forest provide people who have neither the opportunity nor the time to go to fitness centres to exercise in the open air and the project of "Reclaiming green spaces and ocean fronts in limited space in Barcelona" are reported as excellent examples of improving recreation, human health and healthy environments thanks to the contribution of urban forests and greening.

5. Helping to conserve heritage and to add value to landscapes. The city of Lucca, Italy, prepared an inventory of the 1 452 trees within its 15th-century city walls to optimize investments in adaptive management and the conservation of the city's historical urban forest. The province of Rimini, also in Italy, completed a participatory management plan of the Designated Protected Landscape of the Conca Valley, adjacent to the Linear North Adriatic urban agglomeration, as a way of highlighting the cultural landscape and the tourist opportunities of the area.

6. Improving local biodiversity outcomes and protecting nature. The Regional Plan of the Metropolitan Area of Lisbon, Portugal, is a proactive approach to create and conserve green urban areas by integrating them into regional spatial planning. The initiative is being implemented through the Metropolitan Ecological Network with the aims of maintaining connectivity features and ecological continuity and maintaining environmental stability and quality in the metropolitan area.

7. Resolving conflicts between stakeholders with transparent and equitable governance processes through collaborative management and design practices. The implementation of a collaborative management plan for the urban and peri-urban protected area of the Terzolle Valley in Florence, Italy, allowed the integration of initiatives carried out by various groups of citizens and associations, with special concern for the maintenance of

recreation sites and trekking trails. The involvement of stakeholders helped administrators to resolve conflicts of interest over land use (especially regarding hunting and agricultural activities) and to determine the constraints to be applied in the new protected area.

8. Playing a key role in providing ecosystem services. The Ministry of Environment in Tunisia launched a strategic programme to combat and prevent pollution, with the central action being to create urban parks in 20 provinces and 33 municipalities. The number of parks subsequently increased from 22 in 2006 to 36 in 2010. In Barcelona, Spain, the Centre for Ecological Research and Forestry Applications and local institutions prepared a study on the ecological services of the urban forests of Barcelona by applying the Urban Forest Effects Model, leading to a set of recommendations and vulnerability issues to be included in the municipal urban strategic plan.

9. Supporting the provision of clean water and stable watersheds, now and in the future. Large-scale afforestation started in the 1930s in Ankara, Turkey, and continued nationally during the remainder of the twentieth century. According to the Plantations Act from that period, every village and municipality should establish at least 5 ha of forest. With increasing urbanization in the early 1960s, large-scale planning was undertaken by the Erosion Control Division of the Forest Ministry and municipalities in order to stabilize watersheds and counteract erosion and floods. In total, 50 000 ha of urban forests, green belts, road plantations and memorial plantations were established.

10. Enhancing forests and trees as key elements of green infrastructure. The Ecological Network for the Structural Plan of the Municipality of Bologna, Italy, is a working tool for the implementation of an ecological vision for land-use planning at the municipal level. Key elements for strategic planning are the conservation of habitats; landscape continuity; the integration of green spaces having multiple uses; and the improvement of urban and peri-urban forests and tree systems.

11. Providing a healthy environment and improving the quality of life of urban dwellers. In Spain, the University of Granada, in collaboration with local authorities, prepared guidelines to reduce the impact of urban green zones on pollen allergies. The document provides feedback for social health planning and is a key part of urban vegetation management and design.

12. Contributing to the prevention of fire at the wildland–urban interface. The forests close to Beirut and other urban areas in Lebanon are threatened by urbanization processes and forest fire. Local initiatives are emerging aimed at the protection and conservation of peri-urban forests, including the Baabda forest initiative; the Harissa initiative; and, the Nahr Beirut, or Beirut River, initiative.

Conclusion and recommendations

There are three major constraints to assessing the state of Mediterranean urban forests. First, UPF is a young discipline, and this is particularly true in the Mediterranean countries; the term itself is little used in the majority of Mediterranean cities. Second, there is a high diversity of UPF management styles, organizations, institutions, status, skills and expertise, responsibilities and decision-making. The experts dealing with these topics have various backgrounds – they are foresters, agronomists, landscape architects, botanists, environmental scientists, architects and engineers. This heterogeneity makes it difficult to collect comparable information and to engage in effective dialogue. Third, few Mediterranean cities collect information that is comparable at the national level or apply common indicators that could be used in evaluating the state of urban forests in the region. The following recommendations could help overcome these constraints:

- Partnerships should be established between local authorities to connect and harmonize agriculture, agroforestry and forestry. This would strengthen the links between rural and urban activities and approaches.
- The "green infrastructure" concept should be promoted to support and strengthen local and collaborative initiatives in the design, conservation and management of urban and peri-urban forests and tree systems through the inclusive and gender-sensitive participation of stakeholders.
- Mayors and other city administrators and local authorities should be trained in UPF, and, in parallel, international curricula for multipurpose UPF should be developed based on a working model that connects urban and peri-urban forests and tree systems, agriculture, landscape ecology, landscape architecture and strategic planning.
- Guidelines, manuals and reference handbooks should be developed for technical aspects of UPF and governance; lessons learned from UPF practices and case studies should be shared with urban decision-makers, technical and financial partners, and other stakeholders; and a report on the state of UPF in the Mediterranean region should be prepared.
- A definition of UPF and other terms should be agreed in the region; minimum standards should be developed; and the new guidelines on UPF for policymakers and decision-makers should be adapted to the region and implemented.
- Mediterranean UPF should be elevated in importance in regional environmental and planning agendas.
- A short list of key indicators should be developed for the assessment and monitoring of urban forests in Mediterranean countries, such as population density of the urban area; green space per urban resident; the area of green space and urban and peri-urban forests as a proportion of the total urban area; the number of trees (both public and private); the urban form and structure of the city; the coefficient of permeability (*i.e.* the ratio of the sum of permeable areas and the total area); plant biodiversity (*e.g.* the number of plant species per hectare in natural spaces); the average distance between green spaces and built-up areas; the extent of the wildland–urban interface; and plant integration (the ratio of eco-managed area and the total area of the private landlots).

This subchapter on urban and peri-urban forests and other tree systems is dedicated to Michelle Gauthier, a forestry expert at the FAO Forestry Department, who passed away suddenly a month before the publication of State of Mediterranean Forests. Michelle's commitment to urban and peri-urban forestry, and her key contribution to this subchapter, should inspire us for the future and encourage us to implement the recommendations proposed herein for the Mediterranean region.

3

Legal, policy and institutional framework

In the current context of economic and social tensions, ecological crisis and climatic changes, reconciling forest resources conservation and socio-economic development seems delicate.

The international dialogue on forests put the emphasis on this double challenge and appears to influence policies and management strategies in Mediterranean countries. Mediterranean woodlands' multifunctionality is one of their main specificities. The production of non-market goods and services rendered by these ecosystems and their regulations takes an important place in the political and legal frameworks of forest management, whether these are national (*e.g.* in Morocco, Turkey) or sub-national (*e.g.* in Spain, Italy).

Forest policies, strategies and programmes as well as related institutional frames are greatly impacted by the need to regulate pressures on woodlands and to control uses that are often informal. The political, legal and institutional frames for woodlands management are very different among Mediterranean countries, and depend in particular on the more or less strong decentralization as well as on the importance of the forested area. This reduces the relevance of comparisons between countries' political, legal and institutional frameworks. In addition, the analysis is limited by the weak availability and reliability of the data.

Data presented in this chapter originate from the Global Forest Resources Assessment (FAO, 2010b), which contains a set of indicators on policies, legislation and institutions, which are quite limited and incompletely described, as well as from the State of Europe's Forests (SoEF, 2011), which includes a more complete range of indicators, but show gaps and concerns only European countries. Moreover, these formal data do not always enable to approach the reality and similar terms or data can reflect very different situations from one country to another, i.e. as regards National Forest Programmes (NFPs) whose formulation and implementation varies. The synthesis and analysis work is however interesting as it enables to draw a first assessment of existing knowledge, which could be later improved thanks to countries' contributions.

The ownership, use and management of forests and other wooded lands are mainly determined through regulations and directives set by public authorities. At the national level, the frameworks for government action can be examined by analysing political, legislative and regulatory measures, as well as through the importance given to forests in institutions and the resources set aside for them. Although Mediterranean countries all face similar issues (*e.g.* with regard to fire, protection, the production of non-wood forest products and forest health), they address forest management in different ways. Countries in which forests constitute a significant proportion of the total land area and which are major sources of revenue have tended to develop different arsenals of legislation and regulations than countries where forests are less important.

However, the analysis of aspects of the legislative and legal frameworks, such as forestry laws, national forest programmes (NFPs), and institutional arrangements (*e.g.* the ministry of supervision and the level of the main body responsible for forest issues in each country) can help in the understanding of how forests and other wooded lands are managed in the Mediterranean region. These were documented in FAO (2010; see box), and this is the main source for the analysis presented in this chapter. The regional analysis of national budgetary and fiscal systems governing the forest sector would also be useful, but data are too incomplete and heterogeneous for this.

Global Forest Resources Assessment 2010

The effective development and implementation of forest policy depends on the institutional capacity of national and subnational forest agencies. These include, among others, forest administrations, agencies responsible for the enforcement of forest laws and regulations, and forest research and education institutions. Countries were asked to report on these key aspects for the first time in the Global Forest Resources Assessment 2010 (FAO, 2010b), with the aim of addressing a critical information gap in the governance of the world's forests. Specifically, countries were asked to provide information on the following variables:

- the existence of a national and/or subnational forest law, date of enactment and date of latest amendment;
- the existence of a national and/or subnational forest policy and date of endorsement;
- the existence of a national forest programme, its starting date and current status;
- the institutional structures related to forests and forestry;
- human resources in public forestry institutions;
- the number of graduates in forest-related education;
- the number of professional staff in publicly funded forest research centres.

In addition, information was compiled on international conventions and agreements related to forests and the extent to which countries have ratified or adopted these.

3.1 Policy and legal framework

The two fundamental components in developing a national forest management system are the policy framework and the legal framework. The aim of the policy framework is to set a clear direction and management priorities over time, and is mainly expressed in forest policy statements. NFPs or their equivalents can also be used to provide ongoing support in the effort to implement forest policies with follow-up over time, depending on the procedures in each country. The legal framework sets the rights and obligations that apply to the users and other stakeholders of forests.

National policies

Status

Of the Mediterranean countries, 20 completed a FRA report on their forest policies in 2008. Fourteen of those countries, representing more than 84 percent of the total forest area in the

region, responded that they had a forest policy statement. With the exception of Croatia, the six countries that did not have a forest policy statement are SEMCs.
Fifteen countries in the Mediterranean countries (plus Lebanon, where an NFP is being prepared) reported having NFPs in 2010 (ten in NMCs and five in SEMCs). These 15 countries accounted for more than 86 percent of the total forest area, and 11 of them adopted their NFPs after 2000 (Figure 3.1).

Albania has a forest policy statement but no NFP, and Croatia, Egypt and the Syrian Arab Republic reported that they have an NFP but no forest policy statement. Twelve countries indicated that their NFPs were in force, three countries were revising them, and an NFP was being drawn up in Serbia. In addition to Albania, three SEMCs did not report the existence of an NFP.

Of the 20 countries that submitted data, all have legislative frameworks for forests. Egypt, Jordan and Portugal were the only countries to have adopted specific forest legislation and incorporated legal provisions concerning forests into other legislation. In Italy, Portugal and Spain, forests are regulated through subnational legislation (at the level of regional units).

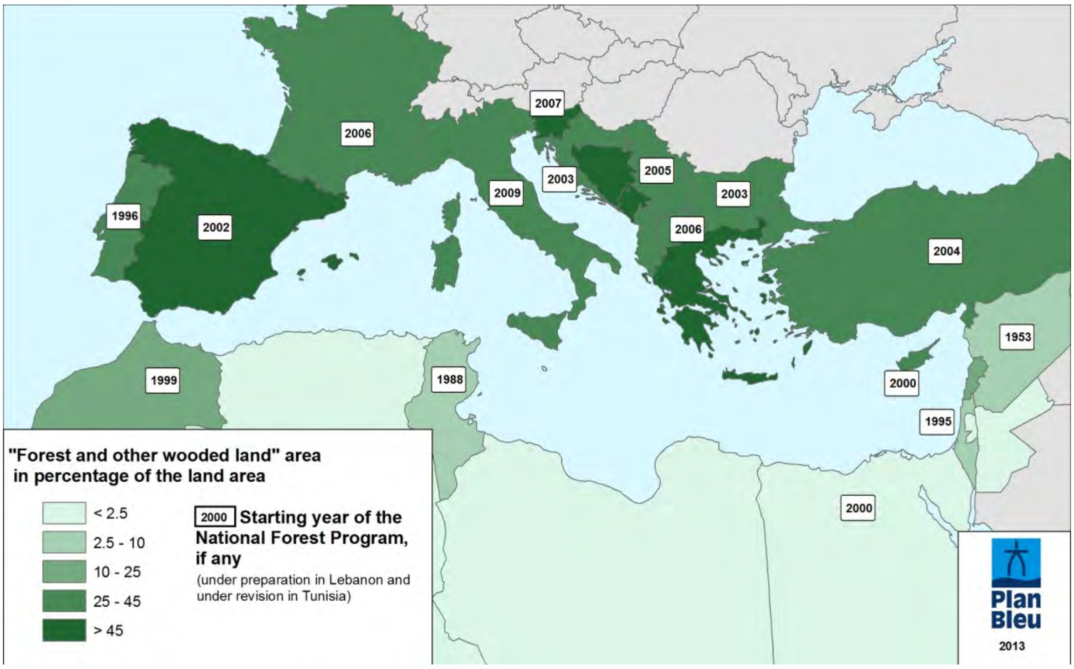

Figure 3.1. ''Forest and other wooded land'' area as a percentage of the land area of Mediterranean countries and starting year of NFPs
Source: FAO, 2010b.

Trends

Of the 14 countries that reported the existence of a general policy statement on forests, 13 had updated their statements since 1995, including 11 since 2000 and 9 since 2005. It appears that countries have widely adopted international commitments for sustainable forest management (SFM) made at the Intergovernmental Panel on Forests/Intergovernmental Forum on Forests (IPF/IFF) and the United Nations Forum on Forests (UNFF), such as to develop NFPs. Eleven of the 16 countries that reported the existence of an NFP in 2010 initiated it after 2000. NFPs appear to be considered a useful tool in formulating and implementing forest policies.

The year in which forest legislation currently in force was enacted varies greatly between countries. Although all 20 countries that submitted data have adopted legal provisions covering forests, forest legislation was dated prior to 1984 in ten of the countries; in those cases, changes to legislation had been made via amendments rather than by enacting new laws. However, six countries had adopted new laws since 2000, and 10 countries reported that their last amendments were made in 2000 or more recently. Morocco was the only country to have made its last amendment prior to 1990 (1976, for a forest law enacted in 1917). In 14 of the 20 countries, legislation currently in effect (adopted or amended) dated back to 2000 at most. Of the six countries where dates prior to this applied, four were SEMCs.

Conclusion

The results of FRA 2010 (FAO, 2010b) indicate that drawing up and issuing forest policy statements became considerably more widespread in the last decade. Governments in the Mediterranean region appear to be giving greater attention to formulating and updating policies directed specifically at forests. If developed and implemented as part of a consistent framework, for example a forest policy statement or an NFP process, such policies can provide effective strategic guidance towards SFM. NFPs have been adopted widely following commitments made within the context of the IPF/IFF and the UNFF. However, depending on how countries apply them, NFPs may simply serve as a programming document similar to a forest policy statement rather than as an ongoing process that supports and provides structure for forest policy development.

Several of the NFP elements are comparatively new in forest policy processes, particularly the strong emphasis on broad stakeholder participation and the focus on intersectoral coordination, especially at the local level. Given the often major departure from traditional approaches, the progress made in adopting and integrating these new elements over a short period varies across countries and will have to stand the test of time.

Most countries reported that they had enacted or amended their forest legislation relatively recently. If legislation is sound and implemented effectively, it should provide a solid foundation for SFM.

Forest-related international conventions and agreements

A number of binding and non-binding international conventions and agreements relate to forests and their management (Table 3.1). Among the non-binding agreements, the Non-legally Binding Instrument on All Types of Forests, adopted by the United Nations General Assembly in 2007, is particularly important. The number of countries in Table 3.1 refers to those countries that have either ratified, acceded to, approved, accepted or adopted a convention or an agreement. Relevant legally binding conventions and agreements include the United Nations environmental conventions and the Kyoto Protocol; although these do not specifically concern forest management, they are frameworks for developing policies in this area once ratified and integrated into national legal frameworks.

Almost all Mediterranean countries had ratified most of the agreements listed in Table 3.1 by 2010, with the exception of the International Tropical Timber Agreement. The latter does not apply to Mediterranean production, but it does apply to imports of tropical timber from member countries.

Table 3.1. Ratification of binding and non-legally binding agreements relevant to Mediterranean forests

Convention or agreement	No. of Mediterranean countries ratified, as of 1 January 2010
Non-Legally Binding Instrument on All Types of Forests	25
Convention on Biological Diversity	24
United Nations Framework Convention on Climate Change	24
Kyoto Protocol	24
United Nations Convention to Combat Desertification	25
Convention on International Trade in Endangered Species of Wild Fauna and Flora	23
Convention on Wetlands of International Importance (Ramsar)	23
World Heritage Convention	26
International Tropical Timber Agreement, 2006	5

Source: Compiled based on information provided on the official websites of relevant institutions.

Institutional framework

The organization of institutional structures responsible for achieving national forest management goals is an indicator of the political importance that countries give to forests. In FRA 2010, countries were invited for the first time to submit information regarding their forest institutional structure, including the ministry in charge of forests and forest policy formulation; the existence of a national forestry agency that reports to the ministry and is in charge of implementing forest projects; the level of subordination to the minister in charge of forest issues; human resource levels, disaggregated by gender and level of education; and administrations in charge of forest management.

Status

Countries were asked to report which ministry held the main responsibility for forest policy formulation in 2008. A total of 20 countries, representing 91 percent of the region's forests, responded. Forest policy formulation is within the purview of the ministry of agriculture in 15 countries, the ministry of the environment in three countries, and the ministry of regional development in one country (Croatia). Morocco is the only country with an administration equivalent to a ministry dedicated to forests – the Moroccan High Commission for Water and Forestry and the Fight against Desertification. The word "forest" appears in the title of the body in charge in nine of the 20 responding countries.

International negotiations to address climate change through a reduction in emissions from deforestation and forest degradation (REDD+) pose a potential challenge to countries where interministerial coordination is ineffective. Such negotiations are typically carried out by representatives of the ministry of environment, even though responsibility for taking action may fall, at least in part, to the ministries of agriculture and forestry. Spain merged these latter two ministries in 2008 to achieve greater efficiency in managing crosscutting issues.

Except in Morocco, where a high commissioner (equivalent to a minister) is responsible for national forests, the person in charge of national forests is directly subordinated to the minister in eight countries. This person was reported to be at the second level of subordination in seven countries and at the third level in four countries.
The level of human resources is an indicator of the institutional capacity available to implement forest policies and laws. In 2008, the public forest institutions in the 20 responding Mediterranean countries had a total of 77 000 staff.

Approximately 17 000 professional staff were employed in public forest institutions in the 20 responding countries in 2008. On average, roughly one in five (22 percent, varying from 18 percent in the NMCs to 26 percent in the SEMCs) of the total staff was a university graduate. There were considerable disparities at the national level: for example, the percentage of university students on the staff was more than 80 percent in Croatia, Serbia and Tunisia and fewer than 10 percent in Egypt, Jordan and Italy.

The total percentage of female staff in public forest institutions in 2008 was 13.5 percent (lower than the global average of 22 percent), ranging from more than 30 percent in Egypt, Portugal and Serbia to less than 10 percent in Cyprus, Lebanon, The former Yugoslav Republic of Macedonia and Tunisia. The number of women in professional staff positions varied greatly between countries, from 40 percent in Portugal to zero in Cyprus among the NMCs, and from 34 percent in Algeria to zero in Jordan among the SEMCs.

Trends

Apart from Bulgaria, where human resource levels declined dramatically (by 85 percent), there was only a slight overall decline in staff numbers in public forest institutions in the 20 responding Mediterranean countries between 2000 and 2008 – 2 percent among the NMCs and 1.5 percent among the SEMCs.

The total number of professional staff in public forest organizations increased by 2 percent between 2000 and 2008 (except in Bulgaria, where there was a decline of 83 percent), with a 20 percent increase in the NMCs (including a 125 percent increase in Portugal) and a 4.5 percent decrease in the SEMCs. The number of women increased slightly over the period, from 13.1 percent to 13.5 percent.

Conclusion

The data presented above were collected according to FRA 2010 (FA), 2010) criteria for the first time. It is difficult to determine their implications for the quality and efficiency of forest management without a more in-depth qualitative study of change over time, as well as country-by-country analyses. The interpretation of the data is far from straightforward and would require more detailed information on institutional capacity, such as the availability of financial resources, skills and expertise, technology, infrastructure and facilities, and the quality of partnerships. Moreover, the requirements for human resources depend on society's expectations about the role and management of forests and how these are reflected in policies. The significant variability in human resource parameters between countries indicates the strong influence of context on them.

Education and research

Information about education and research provides an indication of a country's managerial, technical and administrative capacity for SFM and its ability to adapt the forest sector to new challenges. The number of students completing master's degrees is one indicator of the future national ability to develop and implement policies and strategies for SFM; the number of bachelor's and master's degrees may provide an indication of the capacity to manage programmes and implement policies; and the number of technical certificates or diplomas may indicate the capacity to implement operational plans. The total number of university students who graduate with master's and bachelor's degrees indicates the resources being devoted to training in the forest sector and therefore may indicate the importance of forests and their management in a country. The number of professionals working in publicly funded forest research is an indication of the national interest in, and capacity to resolve, forest sector issues (Figure 3.2).

Status

In 2008, 19 countries representing more than 90 percent of total forest cover in the Mediterranean region reported that, in total, more than 5 700 students completed education in forest sciences. Of this total, 2 831 were university students (873 completing master's degrees and 1 958 completing bachelor's degrees) and 2 913 obtained forest technician's certificates. Some regional disparities may stem from differing education systems. In the SEMCs, there was an average of five graduates with bachelor's degrees for one graduate with a master's degree, while in the NMCs the ratio was 1.7 to 1. The low number of graduates of bachelor's degrees relative to master's degrees in the NMCs was partly because the education systems in many of those countries offer combined bachelor's and master's degrees in forestry, without the need to specifically complete the bachelor's degree.

Figure 3.2. Capacity building for young researchers. Integrated forest inventory training in Egypt for the project "Forest restoration in Algeria, Egypt, Morocco and Tunisia using treated wastewater to sustain smallholders' and farmers' livelihoods".

In the SEMCs, just over 20 percent of staff had forest technician's certificates, compared with 60 percent in the NMCs. The low reported number of graduates with forest technician's certificates in SEMCs was associated with the inherent difficulty in compiling data concerning students studying for this type of diploma. Technicians in many SEMC countries often receive broad technical teaching that includes forestry, agriculture and the environment, and the forestry component is not necessarily mentioned in the title of the programme. Information related to bachelor's and master's degrees appears to be more reliable because it is gathered from universities and forestry faculties where specialized forest programmes are taught.

It can be assumed that a society that educates more students in forest sciences is better prepared to face future challenges concerning forest conservation and management. In 2008, there was one university graduate in forest sciences per 103 000 people in the NMCs and one per 302 000 people in the SEMCs. In both subregions, the ratio of university graduates to forest area was roughly the same, at 250 graduates per 1 million hectares.

In 2008, the proportion of female graduates at the various levels was highest at the master's level, followed by bachelor's degrees and then technical diplomas. There were major differences between the NMCs and the SEMCs: women comprised 45 percent of graduates in the NMCs and 26 percent in the SEMCs at the master's level; 39 percent in the NMCs and 23 percent in the SEMCs at the bachelor's level; and 10 percent in the NMCs and 6 percent in the SEMCs at the technical level.

In total, 13 countries representing 60 percent of the total forest area in the Mediterranean region reported data on research capacity. In those countries combined, approximately 2 000 professionals were working in publicly funded research centres in 2008. Data were unavailable for several countries with large forest areas, including France, Greece and Italy. About 39 percent of the total reported forest research workforce held doctorates, with no significant difference between the NMCs and the SEMCs. There were approximately 17 workers with doctorates per 1 million ha in the NMCs and just over 11 per 1 million ha in the SEMCs.

Trends

Between 2000 and 2008, the number of students graduating with a degree in forest sciences generally increased in the 12 responding Mediterranean countries (represent approximately 73 percent of the forest area). There was an increase over the period in the number of students graduating with master's graduates of about 10 percent, with bachelor's degrees of about 36 percent, and with technical diplomas of more than 40 percent (excluding Bulgaria for methodological reasons). The total number of forest graduates increased by 26 percent over the period.

The number of women studying forest sciences at the university level (bachelor's and master's degrees) increased by 35 percent between 2000 and 2008. The proportion of female university graduates in the workforce increased from 31 percent in 2000 to 33 percent in 2008.

In countries where a time series was reported, the total number of doctoral and master's degrees in the publicly funded forest research workforce was stable between 2000 and 2008 (except in Spain, where there was a 35 percent increase).

Conclusion

There should be sufficient capacity in national forest education and research to generate the information and knowledge needed to sustainably manage forest resources and to meet future challenges. In the Mediterranean region, the increased number of graduates in the period 2000–2008 is encouraging. However, this trend does not appear to be consistent with the slight decrease in staff numbers in publicly funded management administrations (except in the positions requiring the highest educational qualifications in the NMCs, where the number increased) over the same period, nor with the lack of change in staff numbers in public research organizations. Beyond these quantitative observations based on reported data, it is difficult to assess the extent to which existing human resources are equipped with the skills and knowledge needed to meet future needs.

3.2 Public policies

The Mediterranean region is characterized by significant disparities in forest cover between countries. They range from 0.07 percent of the total land area in Egypt to 62 percent in Slovenia. Of the 26 countries that submitted data on forest area, the 11 SEMCs had the lowest proportions of cover (less than 15 percent of the total land area); more than half of those SEMCs reported less than 3 percent forest cover.

Differences in forest cover help explain the variation between countries in forest policies and publicly funded action. In countries with few forests, the absence of a forest policy statement and NFP does not necessarily mean that forests are not given due attention. Rather, they are often included in cross-cutting environmental programmes, mainly to combat desertification, which also includes rural development priorities.

All countries in the Mediterranean region have legal provisions pertaining to forests, but there are significant differences between countries in the existence of forest policy statements and NFPs. Countries with both an up-to-date forest policy statement and an operational NFP are most of the NMCs as well as Israel, Morocco and Turkey, which have some of the highest proportions of forest area among the SEMCs. These countries may be considered particularly active in confronting forest-related issues. Countries with neither an up-to-date forest policy statement nor an operational NFP but that have adopted legal provisions are Algeria, Lebanon, Libya and Jordan. Of these, only Lebanon has more than 1 percent forest cover (13 percent); that country is in the process of preparing an NFP. Croatia, Egypt, the Syrian Arab Republic and Tunisia have NFPs but no recent forest policy statement, and Albania has a forest policy statement but no NFP.

Formal forest public policies

For the NMCs, which represent 88 percent of the Mediterranean forest area, FOREST EUROPE conducts regular overviews of national public forest policies in its *State of Europe's forests* reports. Here, certain elements of the most recent of these reports (FOREST EUROPE, UNECE and FAO, 2011) are presented and analysed, supplemented by information for some other Mediterranean countries.

Land use and forest area

Legal regulations are the most frequently used instruments for maintaining and increasing forest area. The main legal instruments that ensure the implementation of objectives are legal restrictions and procedures for changing land use, such as Forest Acts, management regulations, afforestation/reforestation regulations, and general Land-use Acts. Most of the surveyed countries have an organized national public forest agency responsible for implementing and monitoring national regulations and programmes related to land use and forest area.

All 13 countries with policies specifically on forests have objectives for forest cover – mainly to maintain it at the current level. Four countries – Bulgaria, Spain, The former Yugoslav Republic of Macedonia and Turkey – have an objective to increase forest cover. Of those four, only Bulgaria has not specified a target area or a time frame in which to achieve it. In Spain, the objective was to increase forest area by 45 000 ha by 2012; in The former Yugoslav Republic of Macedonia, the objective was to increase forest area by 70 780 ha by 2020; and in Turkey, the objective was to increase forest area to 1 060 600 ha by 2007.

Some countries indicated a desire not to increase forest area. In Montenegro, for example, the policy was that forest land should not be expanded in certain areas so as to allow profitable agriculture or to preserve the biodiversity of other ecosystems (such as natural grasslands and shrub lands). Slovenia, with a high percentage of existing forest cover (62 percent of total land area), reported a policy to maintain but not increase forest area, although there was an objective to reduce fragmentation.

There were country-specific objectives for land use and forest area in Bulgaria, Croatia and Morocco. In Bulgaria, the legislation on forested land use was updated to facilitate multipurpose use under contractual (renting, leasing) or other land-use rights. In Croatia, forests in certain karst regions and areas affected by landmines, which previously were either unmanaged or managed to only a limited extent, were included in regular management plans. In Morocco, in order to balance forest degradation due to illegal overexploitation, a policy for the reforestation of 33 000 ha per year has been implemented since 2003 (Figure 3.3), together with better control and paid compensation for local communities.

Figure 3.3. Reforestation near a High Atlas village, Morocco.
©FAO/FO5631/Andrea Perlis

To adapt their national situations to changes in the global and European economic and policy environments, most countries updated their legislation in recent years, leading to changes in, for example, forest land use, rights, ownership structure, the definition of forest, multiple forest uses and SFM, and also in institutional arrangements. Greece, for example, adopted a new forest law and changed its definition of forest and other wooded lands in 2010 in reaction to the devastating forest fires of 2007; the aim was to bring more land under the protection of the forest law and to limit rapid land-use change. In addition, the Greek Constitution now prohibits land-use change that involves forest destruction. In Bulgaria, the forest administration was reorganized in 2009 and became the Executive Forest Agency at the Ministry of Agriculture and Food. In Croatia, as part of the reorganization process of the Croatian Government in 2007, the Forestry Department was transferred from the Ministry of Agriculture, Forestry and Water Management to the newly established Ministry of Regional Development, Forestry and Water Management.

Carbon balance and climate change

In line with international commitments and negotiations on the mitigation of, and adaptation to, climate change, many countries have placed stronger emphasis on carbon sequestration by forests and adapting forests to climate change. For example, there are specific efforts to increase the use of wood as a raw material and a source of renewable energy in Bulgaria, France and Montenegro and to reduce national greenhouse gas emissions in Bulgaria, Croatia, Cyprus, France, Italy, Portugal and The former Yugoslav Republic of Macedonia.

EU member states are setting objectives in line with the three principal objectives of the EU Climate and Energy Package 2008, which are to achieve, by 2020: a 20 percent reduction in greenhouse gas emissions below 1990 levels; an increase, to 20 percent, in the proportion of EU energy production and consumption derived from renewable energy sources; and a 20 percent reduction in primary energy use through improved energy efficiency.

SFM is one of the leading concepts defining policies to mitigate climate change in Bulgaria, Croatia, Montenegro and Turkey. Seven of the 13 countries with policies specifically on forests also have climate change policies. In the other six, climate change is mentioned as a factor in other policies.

Slovenia recently adopted measures designed to ensure forest adaptation to climate change, such as the conservation of high growing stock; favouring native species and ensuring natural regeneration for better resilience; the prevention of forest fires; maintaining continuous vegetation cover on forest soils; preventing litter-gathering; and the prompt harvesting of wood from forests damaged by natural disasters to reduce the incidence of bark beetle outbreaks. Spain's revised NFP takes into account the adaptability and resilience of Spanish forests to climate change. To help fulfil requirements under the United Nations Framework Convention on Climate Change and the Kyoto Protocol, Croatia established a Department for Climate and Ozone Layer Protection in 2009 and Turkey established a Coordination Board on Climate Change.

The role of forests in climate change mitigation and adaptation is emphasized in some NFPs (*e.g.* Slovenia) and forest laws (*e.g.* Croatia). The Forestry Act of Croatia (amended in 2008) recognizes the importance of forest carbon sequestration in mitigating climate change and outlines specific measures to increase carbon sequestration in forests. Croatia also established the National System for Calculation and Reporting on Anthropogenic Emissions of Greenhouse Gases by Sources and Sinks, based on the Regulation on Monitoring Greenhouse Gas Emissions in Croatia, which includes forests. Italy adopted a decree on the establishment of the National Register of Forest Carbon Sinks in 2008.

Figure 3.4. Prescribed fire, Spain.
© Spanish Forest Fire Service, Ministry of Agriculture, Food and Environment

Health, vitality and forest fire

In almost all countries, the overall objective of forest management is the maintenance of forest health and vitality and the multiple benefits that forests provide. Some examples of particular policy orientations follow.

The forest policy of the former Yugoslav Republic of Macedonia highlights the implications of climate change for forest health and vitality. In Cyprus, Italy, Portugal and Turkey, forest fire control (Figure 3.4) and mitigation measures are core elements of policies for maintaining forest health and vitality, and there are specific policies on forest fire in France, Greece and Spain.

In addition to Forest Acts, a large variety of legal measures is in place to regulate aspects of forest health and vitality. For example, Bulgaria's policy for maintaining forest health and vitality is based on general forest protection and plant health regulations. Croatia has an ordinance against the introduction and spread of harmful organisms, Montenegro has a national action plan for combating illegal logging, and Spain has a national plan for preventing the spread of pine wood nematodes.

There have been recent changes in the institutional frameworks in some countries in relation to aspects of forest health. In Portugal, new coordination structures were adopted at the level of regional forest management units to improve the implementation of forest fire control and mitigation measures. In Spain, the Ministry of Environment and Rural and Marine Affairs was created in 2008 by merging the former Ministry of Environment and the Ministry of Agriculture, one aim of which was to improve coordination between the national plant health service and the national forest health service. In Lebanon, a national committee to prevent forest fire was set up in 2001 as a joint effort of the ministries of Agriculture, Defence, Environment and Interior. In the Syrian Arab Republic, cooperation with Turkey supported by FAO in 2010–2012 enabled the implementation of a programme to improve forest fire management, including institutional capacity building.

Production and use of wood

Seven of the 13 countries with policies specifically on forests have a policy of maintaining wood production (Figure 3.5). Three countries (Bulgaria, Croatia and France) have policies to increase the wood harvest, while Italy and Spain do not specify a wood production goal at the national level. Morocco's wood production policy is focused on limiting illegal wood collection and does not set a production goal. In Lebanon, wood production is restricted by a public ban (Association for forests Development and Conservation, 2007).

Three countries have goals for the use of wood for energy supply to be achieved within a certain time frame. In France, the goal is to increase the use of wood in energy supply by 40 percent by 2020, to 4 million tonnes of oil equivalent. In Italy, the target is a 20 percent increase in the use of wood for energy supply by 2020, and in The former Yugoslav Republic of Macedonia, a quantity of 955 000 m^3 per year was set for 2010 and beyond. In Morocco, specific measures have been taken since 2005 to financially compensate people for not using forests as pastures in dedicated areas: in 2005–2008, this compensation involved seven associations and a total of 1 700 people in 5 000 ha of forest and compensation worth a total of 1.25 million dirhams per year.

Figure 3.5. Wood production in Spain.
©Pilar Valbuena

In most countries, the most important instruments in regulating the production and use of wood are forest management and development plans, public procurement certification schemes, and building standards and regulations. Other instruments, such as the EU Rural Development Programmes 2007–2013, also provide important financial and extension support – for example, the funding of equipment and forest owners' advisory services in Cyprus, Portugal and Slovenia.

Several countries have specific regulations dealing with bioenergy. For example, Slovenia established a market for low-quality wood and wood residues for energy production, and Croatia's climate change legislation addresses bioenergy.

Protective services

While the main focus of current policies and programmes dealing with the protective functions of forests is on soil and water, the protection of other ecosystem services, such as biodiversity conservation, is a growing concern. In all countries, the main policy objectives regarding protection functions are water and soil protection and flood prevention, in particular preventing landslides and preventing and controlling soil erosion and degradation.

In most countries, the forest law regulates the management of forest protective services, and this is particularly strong in Bulgaria, Croatia and The former Yugoslav Republic of Macedonia. Supplementing forest laws, NFPs provide a policy framework on this issue in Cyprus and Slovenia. In Italy and Montenegro, these protective functions are linked to broader environmental protection as well as to rural development and plant health regulations, while in Portugal, specific EU legislation and policy initiatives form the main policy and legal framework for maintaining forest protective services.

Bulgaria, Croatia, The former Yugoslav Republic of Macedonia and Turkey all recently amended their forest laws (or other specific legislation) to encompass the provision of forest protective services, particularly biodiversity conservation and water protection. Slovenia incorporated objectives on forest protective functions into its NFP and issued a governmental decree on protective forests, in particular to better regulate forest land-use change and to provide management guidelines.

Since 2007, Croatia and Turkey have adopted innovative approaches and set new objectives in their policies to take into account specific environmental issues thought to be relevant for maintaining forest protective functions. In Croatia, the protective functions of forests have thus expanded to include biodiversity protection and the mitigation of climate change. In Turkey, the protective functions have been broadened to encompass landscape integrity, as well as game and wildlife protection.

In most countries, state forest administrations play a crucial role in implementing and coordinating forest legislation on forest protective services. Some countries use economic instruments such as national or international (EU) subsidies and public funds, as well as compensation payments to support various forest protective services. For example, Bulgaria is providing state support for the planting of protective forests, Croatia is collecting “green taxes”, largely to fund measures to secure forest protective functions, and Montenegro pays financial compensation to forest owners to cover reduced timber revenues in protected or protective forests.

Cross-cutting policies

Many forest-related public policies cut across sectors, such as those addressing the multifunctionality of forests, biodiversity and public participation. Moreover, in some SEMCs, especially those in which forests and other wooded lands cover a very small proportion of the total land area, forests may be addressed only in intersectoral public policies.

Production and use of non-wood goods and services

In most countries in the Mediterranean region, the overall objective of forest management is the maintenance of the diversity of forest goods and services and the achievement of a balance among the multiple uses of forest. In the Syrian Arab Republic, all forests are classified as supporting multipurpose activities. In The former Yugoslav Republic of Macedonia, the national forest strategy prescribes promotion and support for small and medium-sized enterprises based on non-wood forest products and services, with a focus on providing job opportunities and income for rural households. In the SEMCs, forests are included in cross-cutting policies as a means for poverty reduction and driving local development, including through grazing management and broader agrosylvopastoral systems. Policies in Bulgaria, Croatia and Cyprus also address non-wood forest products and services as means for ensuring economic viability and to address the need for better information on the economic value of such products and services.

Non-wood forest goods and services are regulated mainly by forest laws. Some countries (Cyprus, Morocco, Slovenia and Turkey) also integrate objectives for non-wood forest goods and services in their NFPs or forest strategies, as well as in rural development programmes (Algeria, the Syrian Arab Republic and Tunisia). Italy and Slovenia have specific regulations for mushrooms and berries.

In countries where some local people rely on non-wood forest products for their livelihoods (mainly the SEMCs), forest goods and services are recognized in the legal frameworks and are regulated, although in some cases regulations may be more directed at forest protection than maintaining livelihoods.

Biodiversity

Increasing efforts are being made to conserve biodiversity in general and forest biodiversity in particular, mainly through the creation and management of protected areas. In most cases, biodiversity policies do not focus specifically on forests and their objectives tend to be general (i.e. to stop the loss of biodiversity) or instrument-oriented (i.e. to increase the extent of protected areas). No country has developed forest biodiversity targets with specific biodiversity indicators.

All countries do have biodiversity conservation policies, however. They are mostly framed by regulatory instruments, including laws on nature conservation and strategies on biodiversity. Some countries (Croatia, France, Montenegro, Morocco, The former Yugoslav Republic of Macedonia and Turkey) have set objectives to enlarge the area of forest under protection or to better identify zones with high biodiversity. In the last five years in Bulgaria, for example, measures have been taken to identify stands with high conservation value and to designate Natura 2000 areas.

Notable objectives include increases in forest protected areas by 2020 of 150 000 ha in Montenegro and almost 300 000 ha in The former Yugoslav Republic of Macedonia. In France, the objective is to increase protected areas (not limited to forests) by 350 000 ha by 2020. In Jordan, the Integrated Ecosystem Management of the Jordan Rift Valley Project, launched in 2007, aims to establish a network of 5–6 new protected areas under a common management scheme using a multistakeholder approach.

In most countries in the Mediterranean region, biodiversity conservation is an explicit objective of SFM and is encouraged by, for example, the retention of habitat trees (*e.g.* old or dead standing trees) in managed forest. Croatia and France have both launched programmes to improve ecological connectivity between protected areas. Spain recently adopted specific strategies for the conservation of forest genetic diversity, including through the use of gene banks.

Public awareness and participation

Raising public awareness, particularly on the protective and socio-economic functions of forests, improving institutional cooperation and communication, and ensuring transparency in forest management are policy objectives in most countries of the Mediterranean region (Figure 3.6). Most countries explicitly recognize the need for public and multistakeholder participation as a crucial component in forest policy, management and planning processes (with recent commitments in Montenegro, Slovenia and Turkey). Tunisia is renewing its NFP process and Lebanon is adopting one, both with specified aims to encourage multistakeholder participatory approaches.

Figure 3.6. Strategic Framework on Mediterranean Forests. Policy orientations for integrated management of forest ecosystems in Mediterranean landscapes. An example of policy objectives for the Mediterranean region.

Bulgaria and The former Yugoslav Republic of Macedonia both have objectives to ensure or improve transparency as an important principle of good forest governance and public participation, and Montenegro issued guidelines on how to establish a forest information system and how to ensure public access to information about the forest sector and forests. The need for transparency in forest policies is stimulating the updating of legislation, institutions and NFPs in several countries. In Slovenia, a special organization has been created to undertake forest education and convene multistakeholder thematic workshops and public hearings into processes of adopting forest management and hunting plans. However, there has been much less progress towards greater transparency and participation in forest-related processes in most countries in the south of the Mediterranean region.

Programmes for combating desertification

In most SEMCs, combating desertification is one of the main pillars of environmental policies. All SEMCS have ratified the United Nations Convention to Combat Desertification, and all except Lebanon have national plans for combating desertification.

Forests are mentioned in all national plans for combating desertification. Ensuring that forests are maintained through improved management and by controlling illegal logging, and increasing forest area through tree-planting, are cited as priorities. Tunisia's plan, for example, encourages reforestation and the regeneration of forest and esparto grass as a way of both limiting resource degradation and increasing the quality of life of rural people by improving pasture in forest areas. The importance of wooded lands in maintaining non-arid areas and animal husbandry practices to fight poverty is also acknowledged in plans for combating desertification in Algeria, Jordan and the Syrian Arab Republic.

Algeria's national reforestation plan specifies a target of 3 million hectares to help reduce pressure on existing resources. This is also an important mission of Jordan's Forest Directorate, which includes an Afforestation and Nurseries Division. An objective of reforestation in that country is to "expand areas under forest vegetation and improve forest quality with plantations and extensive afforestation of bare or degraded lands best suited for forest crops". This is also one of the main focuses of Tunisia's NFP. In Egypt, where forests cover less than 0.1 percent of the country, the National Action Programme to Combat Desertification includes using treated sewage water for afforestation, with associated benefits linked to food security and public health.

For the majority of the SEMCs, combined measures to combat desertification and poverty constitute the frameworks for government action on forests.

Discussion

Policies concerning forests are evolving rapidly and are being implemented in all Mediterranean countries. Almost all countries have NFPs and are creating policies on related themes such as climate change, forest health, fire and the protective functions of forests. Efforts are being made to increase involvement in and awareness of forests (see for example Box 3.1), but there is still a lack of participatory processes in some countries and there are also issues related to multipurpose forest management.

In arid and semi-arid SEMCs with relatively small forest areas, policies tend to be more cross-cutting and associated with desertification, and significant afforestation efforts are being undertaken. In general in countries in the Mediterranean region, there has been considerable development in policies on forest protection in the last decade. However, effort is still needed to manage the many pressures on forests.

Although there is increased political interest in forests, this does not translate automatically into enlightened policies. In many countries, there is scope for increased stakeholder participation in policy development and implementation, and increased institutional capacity and transparency.

Projet cofinancé par le Fonds Européen de Développement Régional (FEDER)
Project cofinanced by the European Regional Development Fund (ERDF)

Box 3.1. QUALIGOUV project: Improving governance and quality of the forest management in Mediterranean protected areas

Objectives

QUALIGOUV, a project implemented in 2009–2012, aimed to develop practical and participatory ways to value and enhance the sustainable management of Mediterranean wooded ecosystems.

The ecosystem and social services provided by Mediterranean forests are often more valuable than wood production. Forest uses in the Mediterranean region thus involve a large range of stakeholders (*e.g.* private landowners, states, public agencies, local communities and NGOs), raising complex governance issues. However, ecosystem and social services are not easily marketable and generate limited resources to finance forest management and deal with governance issues.

Thus, QUALIGOUV aimed to help multiple stakeholders in various forested pilot sites (in France, Italy and Spain) (Figure 3.7) to develop governance processes and to test related tools for managing these forests, and to exchange experiences. The project focused on enabling stakeholders to participate in the successive stages of a sustainable management process: the definition of objectives; the development of policies, plans and programmes; implementation; and monitoring, reporting and evaluation. The project was coordinated by the Region of Murcia (lead partner), with the support of the International Association for Mediterranean Forests for synthesis, communication and capitalization actions; a steering committee; and a peer review group comprising independent experts.

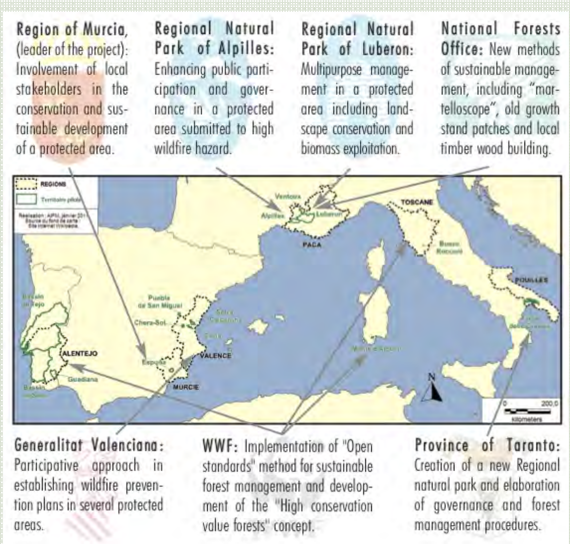

Figure 3.7. Project partnerships and localization of the pilot sites and main activities
Source: AIFM, 2012

Main outcomes of QUALIGOUV project

Based on the ongoing analysis of pilot activities, the peer review group identified three essential phases in the development of a participatory approach aimed at improving governance of a protected area in the Mediterranean:

- the diagnosis – a shared vision of the initial socio-economic and ecological situation in the area, which enables the clear identification of the stakeholders involved in managing the area and their relationships;
- the identification of common goals related to nature conservation and sustainable development, and the collective definition of the required actions to achieve those goals;
- the establishment and maintenance of a consultation body, which ensures that initial proposals are implemented and monitored, to prevent possible drifting.

The following common conclusions and guidelines or recommendations for improving governance in Mediterranean woodlands were identified:

- value the past and current practices to ensure successful economic and social achievements;
- develop approaches closely fitted to local conditions in terms of ecological characteristics, the social and economic situation, and institutional and stakeholder aspects;
- involve, from the beginning, the largest spectrum of stakeholders as possible, as well as local institutions and authorities;
- improve interregional cooperation – beyond the diversity of local situations, there are many common problems. Sharing experiences is very fruitful for field managers;
- develop common tools to tackle these problems in order to improve forest management and governance.

Beyond these results, QUALIGOUV helped to strengthen networks and to build, progressively, a shared vision for Mediterranean forests, which addresses their specificity and allows for better consideration at the international level.

More information can be found in the final capitalization report of the QUALIGOUV project and at http://aifm.org/nos-activites/projets-de-cooperation/qualigouv.

Conclusion

Forest policies in the Mediterranean region must deal with an increasing need to value ecosystem services, which are essential for human well-being but are increasingly threatened by climate change. At the same time, national and regional public authorities are increasingly less able to fulfill its policy development role, due to decreasing financial resources and the increased questioning of “top-down” approaches. Some government functions could, in certain situations, be substituted by market mechanisms (*e.g.* payments for ecosystem services), but these are unlikely to match the need. Moreover, the implementation of such market instruments requires efficient and transparent local governance.

For similar reasons, it is difficult to develop “green economy” policies in the Mediterranean context, the forests and woodlands of which are characterized by their multifunctionality, low productivity and the central role of non-market services. Financing forest management remains a challenge, but it is crucial for ensuring the production of multiple goods and services. Innovative instruments should be developed and tested to address the current challenges and constraints.

4

Mediterranean forests and climate change

This chapter examines the implications of climate change for forests in the Mediterranean region and sets out some of the measures that could be taken to minimize its impacts. Regional projections of climate change are outlined in Chapter 1.

Biodiversity, forest genetic resources and climate change

The Mediterranean region is one of the world's biodiversity hotspots for its outstandingly high plant species richness and endemism (Médail and Diadema, 2009). The onset of the Mediterranean climate and the global cooling and Messinian salinity crisis of the late Tertiary played major roles in shaping the diversity of Mediterranean species (Thompson, 2005). The Mediterranean region was also a major and complex refugial zone during the cold periods of the Pleistocene and, as a result, plant (particularly tree) genetic diversity is also outstandingly high (Hampe and Petit, 2005; Fady, 2005; Fady and Conord, 2010).

People have been using – and affecting – this biodiversity for millennia. Although it has resulted in the rise of original habitats and landscape structures, the interaction between humans and biodiversity has often led to the decline and disappearance of species and populations (Blondel and Aronson, 1999). Climate change poses another formidable challenge to biodiversity in the Mediterranean region.

Forest genetic resources (FGRs) are defined as the part of within-species genetic diversity found in forest trees of actual or potential use to humankind. Only 2 500–3 500 of the 60 000+ tree species that exist on earth (Grandtner, 2005) have been registered as forestry or agroforestry species (Simons and Leakey, 2004), and the term FGRs tends to refer to the genetic diversity of a limited set of adaptive traits in this subset of tree species. However, under changing environmental conditions, new species as well as new traits could be of interest to humankind, and the definition of FGRs has lately come to mean the genetic diversity of woody species as a whole.

FGRs cannot be conserved, managed or used without considering the ecosystems in which they occur. Although the spatial patterns of FGRs and the processes that shape them are becoming better understood, at least for a small number of species of high ecological and economic importance, the future of FGRs under climate change is very uncertain. This is particularly true in the Mediterranean region, where information on FGRs is still limited and where the climate is expected to become drier and hotter, with an increasing frequency of extreme events (heat waves, frosts and storms) and with strong regional variability (IPCC, 2007b). Action is therefore needed to better understand how FGRs are structured in the Mediterranean region.

Importance and vulnerability of FGRs in the Mediterranean region

Pleistocene climate cycles are generally acknowledged as the major determinants of modern genetic diversity (Hewitt, 1999; Petit, *et al.*, 2003). During the long cold periods of the Pleistocene cycles, the Mediterranean region provided suitable habitats for numerous taxa. Because of the geomorphological complexity of the region and its associated sharp microclimatic variability, restricted gene flow and founder events, selection under local environmental conditions and secondary contacts during migration periods have given rise to a rich and diverse FGR.

There were many glacial refugia in the Mediterranean during the last Pleistocene glacial cycle and, consequently, Mediterranean FGRs contain a significant part of the genetic diversity found in forest tree species in Europe and the Mediterranean region. Current habitats are a patchwork of refugial and recolonized habitats (Figure 4.1), where not only drift but also recolonization and local adaptation may have shaped FGRs (Conord *et al.*, 2012; Grivet *et al.*, 2009). Millennia-long human activities (*e.g.* forest-to-agriculture land conversion, forest fire and urbanization) have further restricted gene flow and drift, and many populations are now ecologically and geographically marginal.

Figure 4.1. A marginal population of *Abies alba* on Montagne de Lure in the south of France: recolonization of grassland grazing habitats (125–2506 m above sea level)
©Bruno Fady

FGRs in the Mediterranean region may thus be both precious for adaptation and inherently vulnerable to global change (particularly at their ecological and range margins). Aleppo pine (*Pinus halepensis*), for example, demonstrates considerable genetic variability in its drought resistance, but its most drought-resistant genotypes show strong sensitivity to winter frost (Bariteau, 1992). In temperate regions of Europe, where the climate might become Mediterranean-like in a few decades, FGRs of the more cold-resistant Brutia pine (*Pinus brutia*) will be of strong interest. On the other hand, the most drought-resistant FGRs of Aleppo pine might be unable to survive in regions where frosts will still occur. They may therefore be unable to resist desertification and could be at risk of extinction in their southernmost distribution.

Possible FGR responses to climate change

Tree species in the Mediterranean region are adapted to several climatic conditions, such as summer drought, late spring frost and severe winter frost, depending on site. Even the low range of climate-change scenarios predicts a worsening of these conditions, with increases in mean temperature, the length of summer drought (Mátyás, 2007) and the frequency and intensity of extreme events (IPCC, 2007b).

FGRs may respond in various ways to environmental change, including migration to track the geographical shift of areas that provide suitable environmental conditions (Parmesan and Yohe, 2003); acclimation through phenotypic plasticity (*i.e*. the change in functional traits expressed by an individual in response to environment change across its lifetime; Chevin and Lande, 2010); evolutionary adaptation (*i.e.* a change in gene frequency from one generation to the next resulting in a change in fitness; Kawecki and Eber, 2004); and changes in the forest community (van der Putten *et al.*, 2010).

It is often considered that migration was the dominant factor in shaping genetic diversity during the Pleistocene (Petit *et al.*, 2003). However, despite past glacial and postglacial migrations of many taxa (inferred from fossil pollen records and genetic data), which suggest a robust capacity for range shifts, the migration potential of several species today is considered insufficient to keep pace with projected rapid future climatic change (Loarie *et al.*, 2009). Evolutionary adaptation can also be very rapid: major shifts have been demonstrated over only a few generations, such as increased drought resistance and growth in *Cedrus atlantica* (Lefèvre *et al.*, 2004) and epigenetic-based shifts in bud-break phenology in *Picea abies* (Yakovlev *et al.*, 2012). There are examples in the Mediterranean region of local adaptation in trees (although they are mostly phenological), especially from "common gardens"[9] and *in situ* experiments (Savolainen *et al.*, 2007; Vitasse *et al.*, 2009). Phenotypic plasticity has been demonstrated to be an efficient response mechanism to change (*e.g. Cedrus atlantica*; Fallour-Rubio *et al.*, 2009).

Challenges for management and policymaking

Climate change could have implications for the forest ecosystem services needed for human well-being, such as water cycling, carbon sequestration and the production of

[9] ''Common garden'': field test in which many individuals (clones, families, populations) of a given plant species sampled from an identified geographic area are grown in a common environment, making it possible to infer genetic information from the observation of phenotypic differences.

numerous wood and non-wood products (Millennium Ecosystem Assessment, 2005). FGRs also face other challenges: Sala *et al.* (2000), for example, showed that land-use change and biological invasions remain key drivers of biodiversity change in Mediterranean biomes. Nevertheless, all forest management decisions should now take climate change into consideration, but how to take the uncertainty associated with climate change into account in management plans is a formidable challenge.

In a region where fragmentation is high because of geomorphology and the long history of human activities, it is unlikely that the migration of plant species and forest types will be fully able to ameliorate the impacts of climate change on forests. Even where migration is possible, societies may be unwilling to accept massive forest dieback in some areas and the subsequent natural selection of more suitable genotypes, and may demand intervention. Societies may also be unwilling to accept a substantial reduction in the productivity of high-yield forests as a consequence of phenotypic plasticity.

Some of the challenges that forest managers will face in developing strategies under the uncertainties of climate change are listed below. For each challenge, research is already providing management options.

Revision of seed zones and provenance delineation. Almost universally, forest reproductive materials (FRMs) are used in forest plantation projects according to guidelines written under the assumption that local soil and climatic conditions will remain stable. The Organization for Economic Co-operation and Development (OECD) is the main reference for FRM certification and standardization in the Mediterranean region, but the European Directive 1999/105/CE also provides general criteria and guidelines for FRM trade within the EU. According to most climate models, climatic conditions in the region will not remain stable in the next decades and there is a need to revise rules on the delineation of species' provenances and the transfer of seeds and other reproductive materials. Under this framework, the FAO *Silva Mediterranea* Working Group 4 on Forest Genetic Resources in the Mediterranean Region and International Union of Forest Research Organizations (IUFRO) Working Party 2.02.13 focus on the creation of common criteria for selecting appropriate FRMs and conserving FGRs. For example, Topak (1997) inventoried the FRMs used for reforestation in 17 FAO *Silva Mediterranea* countries that use the OECD standards. Moreover, the FAO *Silva Mediterranea* database lists national and international forest tree common gardens in the Mediterranean region. Basic information such as this is essential for rethinking seed zone delineation and provenance selection in the face of climate change.

Assisted migration. In a fragmented landscape, many species may be unable to migrate to suitable habitats and could go locally extinct. Human land use may also present an impediment to gene flow among populations. In situations where plants are prevented from migration, human intervention may be necessary to prevent extinction. This can take the form of "assisted migration" or "managed relocation", a set of techniques to ensure the maintenance of (forest tree) populations in a changing global environment through the intentional creation of populations beyond the boundaries of their present range (Ducci, 2011). Assisted migration has far-reaching consequences, well beyond the technical problems of physical translocation, for all dimensions of community ecology, conservation and socio-economy (Richardson *et al.*, 2009). These would need to be addressed by forest managers and policymakers.

Change in density and species composition. Forests can be managed to reduce the vulnerability of forest plant communities or to aid their recovery. In either case, management actions can alter the structure and composition of the forest. For example, tree spacing and density can be altered to reduce susceptibility to drought. Managers can also change the composition of species to reduce the vulnerability of forests to disturbances, for example by planting species that are less vulnerable to fire, drought, wind, insects or pathogens or that are better suited to a changed climatic regime. Changes in tree density will also affect genetic diversity within species (Sagnard *et al.*, 2011). Establishing a range of densities will offer alternatives in which natural selection can occur; in this way, managers can alter the FGRs in different stands with the same composition of species.

Monitoring genetic diversity and adaptability. Genetic diversity is essential for the adaptability of tree populations and a system is therefore needed to monitor the dynamics of tree genetic diversity and to detect changes in it. An early concept in monitoring the impact of forest management on genetic diversity, developed by Namkoong *et al.* (1996), uses genetic and demographic indicators to evaluate the efficiency of management actions that drive genetic processes, such as genetic drift, migration and selection, to maintain existing levels of genetic diversity. Such monitoring is the only way to evaluate the long-term sustainability of forest management. It can include quantitative assessments of molecular genetic variation at either the neutral or adaptive level and can also use ecological alternatives as proxies in rapid assessments. Major advances are being made in genomics and with statistical tools to improve the efficiency and cost-effectiveness of genetic monitoring (Schwartz *et al.*, 2006). Neutral genetic markers such as microsatellites have become efficient tools for studying genetic variation and inferring demographic processes (Chybicki and Burczyk, 2010). Recently, evidence of association between single nucleotide polymorphism (SNP) and adaptive traits has been found in forest trees (Holliday *et al.*, 2010; Eckert *et al.*, 2009).

Creating FRMs in breeding programmes

Traditional forest tree-breeding has mostly been concerned with improving the yield and wood quality of a few commercially important species. Tree-breeders are now recognizing that this paradigm must change. For example, an IUFRO conference on low-input breeding and the genetic conservation of forest tree species, held in 2006 in Antalya, Turkey (Fins *et al.*, 2006), agreed that:

> *current and emerging biotic and abiotic stresses and long-term climate change require a broader genetic base in breeding and conservation programs. In addition to broadening the genetic base, program managers should consider traits not directly*

related to increased wood production in breeding and conservation efforts. Examples include drought tolerance and emerging disease–pest resistance.

Common gardens offer an opportunity for low-input breeding, which is the phenotypic selection of the best-performing genotypes (*e.g.* most drought-resistant provenances or above-average trees in specific environments) at relatively low cost using high-performance scientific knowledge, technologies and methodologies. More than ever, selection processes that maintain adaptive genetic variation will be a necessity for Mediterranean tree species, and low-input breeding is an option that should be considered. Common gardens, which are distributed across the Mediterranean and involve a number of tree species, offer an opportunity for monitoring the effect of environmental changes on FGRs over time and space. Thus, common gardens are both models for understanding local adaptation and phenotypic plasticity and tools for selection (see techniques and materials listed in international programmes such as Noveltree, Treebreedex and Trees4Future). Low-input breeding strategies must also move out of orchards and into the forest, particularly when seed collection is done. Breeding for a large genetic basis means collecting seeds from enough trees (typically more than 20, and ideally at least 30) within a neighborhood and mixing them among populations from a region of provenance. Tree-breeding programme managers should aim to create a strategic balance between breeding and conservation and include a conservation component in their programmes (see also Koskela *et al.*, 2007).

Safeguarding FGRs in southern populations of widespread European species

In many cases, the southernmost populations of otherwise continental or Atlantic climate European species are fragmented and isolated (Figure 4.2). Because they are at the xeric end of their distribution range, they are already threatened and will be even more so in the future for a number of reasons, including climate change (Mátyás *et al.*, 2009). Their likely future is increased isolation and fragmentation, increased demographic erosion and the loss of genetic variability, leading to extinction when there is a rapid isotherm shift in latitude and altitude (some populations may survive on mountain slopes where migration to higher elevations is possible; Loarie *et al.*, 2009). Under such a scenario, valuable genetic information may be endangered or lost if a population is locally adapted or otherwise carries genes found nowhere else within the distribution of the species. Safeguarding marginal FGRs may be most important but socially problematic at low elevations, where human impacts can be intense and local adaptation might be strong.

Figure 4.2. *Pinus heldreichii*, Mount Pollino northern Calabria, Italy: an isolated population at a higher elevation
© Fulvio Ducci

Safeguarding marginal and/or peripheral populations in Mediterranean species

The Mediterranean region is home to a tremendous variety of species and FGRs that are important for forestry locally. In the first stages of climate change, Mediterranean habitat pines, evergreen oaks and other tree species may be initially less endangered than central–northern temperate habitat species because they are generally better adapted to drought (see Aussenac, 2002, for *Abies* species). However, with the projected drying of the climate, increases in weather extremes and related events such as forest fire, and shifts in human activities such as agriculture and grazing (particularly in the southern Mediterranean), Mediterranean FGRs will come under increasing pressure.

Isolated populations of many Mediterranean species (*e.g. Alnus cordata*, *Pinus nigra* v. *laricio* and *P. heldreichii*, cedars and Mediterranean firs) are growing at their ecological or geographical margins. Most are small and scattered and have been affected by genetic erosion in the past. At the same time, there is increasing evidence that local adaptation may have played a significant role in shaping genetic diversity of populations of Mediterranean species (Grivet *et al.*, 2011). Action for the conservation of such marginal or peripheral populations of Mediterranean forest tree species should be a high priority (Figure 4.3).

Figure 4.3. *Pinus nigra pallasiana* in the Trohodos Mountains in Cyprus. Although its habitat is protected, regeneration of this isolated FGR is scarce, and its future uncertain under climate change
©Bruno Fady

Conclusion

Mediterranean FGRs are both diverse and vulnerable. Understanding how much genetic diversity is available and needed for adaptation (in a broad sense) under climate change remains a challenge. Forest trees, unlike most crop species, still exist in natural populations that harbour a wealth of genetic diversity; this diversity can be exploited in breeding but will also assist tree populations to adapt in a changing environment. Innovative approaches are needed to investigate the molecular basis of adaptation in forest tree species. Specifically, research is needed to better understand the functions of genes and to measure and characterize the genetic diversity of natural populations to determine how it relates to the enormous phenotypic diversity found in trees.

Next-generation sequencing (NGS) technologies could be useful in such investigations. NGS has been used recently for whole-genome sequencing and for re-sequencing projects in which large numbers of SNPs are used for exploring within-species diversity. Methods that allowed for high-throughput genotyping have greatly increased the speed and precision with which genes involved in adaptation can be localized. Several microarray-based marker methods for scoring SNPs have been developed for forest trees that can allow the genotyping of hundreds or thousands of markers simultaneously (*e.g.* in *Pinus* *pinaster*). The increased ability to sequence, in a cost-effective manner, large numbers of individuals within the same species has altered the concept of SNP discovery and genotyping in genetic studies, especially in plant species with complex genomes or where public resources are limited (often the case for forest tree species). A new concept has emerged called genotyping-by-sequencing whereby sequences are used to detect and score SNPs. Several of these tools are now available (or work is in progress for their development) for Mediterranean species (*e.g.* Aleppo and maritime pine, *Taxus baccata* and oak species).

Experimental tools to measure phenotypic and genetic diversity are also available, such as the 30-year-old research network of more than 800 field (common garden) sites in the Mediterranean region established by FAO *Silva Mediterranea* in cooperation with IUFRO Working Group 2.02.13. These common garden sites make it possible to compare FGRs in controlled environments and thus to assess the extent of genetic diversity for a given trait of interest. It is also possible to compare the same FGR in different environments to assess the extent of phenotypic plasticity for a given trait of interest in different populations.

In addition to filling research gaps, the overall challenge for management is to make best use of existing knowledge and to ensure continued expertise through training and extension that matches local needs. In Mediterranean countries (where an integrated political structure is yet to emerge), a major challenge is to ensure the simultaneous pursuit of conservation, use, preservation and local development. Experimental international trial networks spread across Mediterranean countries (mostly for conifer species but also for cork oak; Besacier *et al.*, 2011) need to be re-activated on a large scale to support new research approaches to study the genetic bases of adaptation and to generate recommendations for using FRMs in the face of climate change. These resources are inventoried in a database established in 2007 within the framework of the European project Foradapt, developed by INRA Avignon and *Silva Mediterranea* partners, and partially within the framework of the EU project Treebreedex.

Several initiatives are under way to help meet the above challenge. These include cooperation initiatives by several countries in the southern Mediterranean; and a COST Action titled "Strengthening conservation: a key issue for adaptation of marginal/peripheral populations of forest tree to climate change in Europe" involving European countries and most of the *Silva Mediterranea* partners as well as international institutions such as FAO, IUFRO, the Mediterranean Regional Office of the European Forest Institute (EFIMED) and the European Forest Genetic Resources Programme (EUFORGEN). In all these activities, the correct use of FRMs is considered fundamental to protecting and increasing the sustainability of forest ecosystems.

The Mediterranean Forest Research Agenda is a parallel initiative managed by EFIMED designed to encourage better connections between researchers; the implementation of the principles of sustainable forest management; and the first implementation at the pan-European level of the commitments made in the framework of the Ministerial Conference for the Protection of Forests in Europe. The Mediterranean Forest Research Agenda is designed to address the main scientific priorities and challenges of Mediterranean forests.

Finally, although actions taken at the interface between science, policy and management are necessary, it is important to note that much needed scientific information is still lacking, particularly on the distribution, ecology and genetics of Mediterranean forest tree species, and new research initiatives in these areas are needed. These should be prioritized by, for example, focusing first on endangered tree species, choosing model species for various climatic situations or altitude ranges, or choosing model species to represent a number of genera. These options are not necessarily mutually exclusive, and science–policy–management interactions are needed for prioritization and to take action for adapting Mediterranean forests to the challenges posed by climate change.

Adaptive management and restoration practices in Mediterranean forests

The future of Mediterranean forests and the sustainable delivery of their goods and ecosystem services are threatened by the rapid climatic changes that the region is experiencing (Palahi *et al.*, 2008; FAO, 2010a; see Chapter 1). These climatic changes have caused or contributed to tree mortality across the Mediterranean region (Bentouati, 2008; Chenchouni, Abdelkrim and Athmane, 2008; Semerci *et al.*, 2008) and are having negative impacts on the carbon and water balances of many Mediterranean forests (Martínez-Vilalta *et al.*, 2008; FAO, 2010a).

The already harsh climatic conditions for forest growth are projected to continue to deteriorate under all the Intergovernmental Panel on Climate Change (IPCC) greenhouse gas emissions scenarios. Such changes in climatic conditions have major implications for the future functioning and sustainability of Mediterranean forest ecosystems (Lindner *et al.*, 2010). Beyond vulnerability assessment, these changes require adaptation using appropriate existing practices and the development of innovative practices. Adaptive strategies are required to cope with multiple uncertainties about the impacts of increases in the frequency and intensity of extreme events; the capacity of current ecosystems to respond to changes; potential tipping points; the response of complex biotic interactions; and future responses to current adaptive measures. Therefore, adaptive strategies, including local-scale (*e.g.* silviculture and forest planning) and large-scale (*e.g.* land uses and regulations) activities, should be robust and flexible, and exit strategies might also be needed (*e.g.* to diversify rather than restrict the portfolio of forest reproductive material offered for use in plantations).

The importance of Mediterranean forests under climate change is threefold. First, projections of climate change in the region are particularly severe and the region's forests provide the main gene pool for future adaptation. Second, Mediterranean tree species that are threatened in their current ranges are potential resources for use elsewhere. Third, current Mediterranean forestry systems can provide know-how to other regions that could experience Mediterranean conditions in the future.

Water management

Most Mediterranean forests grow under water-limited conditions, with potential evapotranspiration higher than precipitation and actual evapotranspiration comprising up to 90 percent of annual precipitation. Trees are unable to reach their full potential level of transpiration, restricting the amount of carbon that can be fixed. Projected climatic changes will exacerbate these conditions.

Up to a certain point, forest management and planning can help to reduce tree water stress and increase the survival of forest stands. Management practices can also help to maintain or increase the biomass produced in a stand using less water (*i.e.* better water-use efficiency).

The volume of water used by trees in forest plantations depends to a large extent on stand age (Farley, Jobbagy and Jackson, 2005; Jackson *et al.*, 2005) but depends mainly on variables such as leaf area index and canopy roughness. Both these are amenable to management control, and several proposals have been made (Vanclay, 2008).

Thinning may decrease the susceptibility of trees to drought stress by increasing the availability of resources to the remaining trees (Gracia *et al.*, 1999; Gyenge *et al.*, 2011). Thinning may also improve plant water status and water-use efficiency (Ducrey and Huc, 1999).

Gas exchanges between trees and the atmosphere above the canopy depend to a certain extent on the structure of the canopy. The high degree of heterogeneity of tree height and shape in mixed forests creates wind turbulence that facilitates gas exchange in such forests. Planted mixed-species forest stands may have higher canopy roughness than even-aged pure stands, which may reduce transpiration (Forrester, 2007); thus, they can continue carbon fixation when atmospheric conditions become limiting for fully exposed crowns. Plantation design can modify atmospheric coupling of forest plantations by, for example, the use of mixed species or softening plantation edges through thinning and pruning.

Plantations of mixed species may have greater production efficiency (*i.e.* the transpiration:assimilation ratio) compared with pure stands. For example, *Acacia mearnsii* and *Eucalyptus globulus* doubled their production when planted together in mixed stands (Forrester, 2007). This is probably due to the heterogeneous structure of such stands (tree height and shape).

Integrated fire management

Integrated fire management is a concept for planning and operations that include social, economical, cultural and ecological evaluations with the objective of minimizing the damage and maximizing the benefits of fire. Integrated fire management combines prevention and suppression strategies and techniques and the use of prescribed and traditional burning (Rego *et al.*, 2010) (figure 4.4).

Figure 4.4. Prescribed burning in Spain
©Spanish Forest Fire Service, Ministry of Agriculture, Food and Environment

Rather than viewing fire as a disaster, integrated fire management tackles its full range of effects, both detrimental and beneficial. Fire has always been used for various purposes in the Mediterranean region, but the benefits of fire are in danger of being forgotten. These two aspects of fire – its detrimental and beneficial effects – represent the so-called paradox of fire. Fire is used in rangeland management and agriculture, as well as in forests, and the long fire history in the Mediterranean region has created ecosystems that need fire for their sustainability.

In integrated fire management, the objective is to minimize the inappropriate use of fire and to maximize its appropriate use. Appropriate use includes good practices in the traditional use of fire, prescribed burning, and suppression fire. Rural communities have traditionally used fire for land and resource management based on accumulated know-how. Prescribed burning is the application of a fire under specified environmental conditions that allow the fire to be confined to a predetermined area and to attain planned resource management objectives. Suppression fire is the application of a fire to accelerate or strengthen the suppression of a wildfire.

The concept of integrated fire management was developed outside Europe but was recently proposed for Europe under the project Fire Paradox and could be extended to the Mediterranean region (Silva *et al.,* 2010). Usually, integrated fire management involves community-based approaches, sometimes called community-based fire management, which integrate the activities and make use of the capabilities of rural people to meet the overall objectives of land management and forest protection. There is a need to regulate traditional fire use. On the other hand, in some regions, good practices in traditional burning have been maintained and should be consolidated. Community-based fire management requires a permanent dialogue between professionals and the rural population and an acknowledgement of the need for fire use. Recognition of the fact that fire exclusion isn't appropriate for many Mediterranean forest types is very recent. A move from a fire exclusion policy towards a "learning to live with fire" objective is needed, since fire won't be eliminated from the Mediterranean environment, with its human-dominated fire regime. This vision, including an intersectoral consideration of the multiple purposes of fire use, should drive approaches on public awareness and increase community fire preparedness and response capacity, especially at the wildland–urban interface.

Using and preserving forest genetic resources in forestry and habitat conservation

FGRs are an essential resource for forest adaptability in the face of an uncertain future (see ''Biodiversity, forest genetic resources and climate change''). On the time scale foreseen for climate change – that is, a few generations of trees at least – the challenge is to combine two objectives: to accelerate the genetic adaptation of tree populations to new environments; and to preserve their adaptive capacity for further evolution. The value of FGRs is not limited to traits of interest today, such as drought resistance: given the multiple uncertainties about future biotic and abiotic environmental constraints (*e.g.* the emergence of new diseases), the full suite of diversity needs to be conserved.

To ensure this, more may need to be done, in particular related to the following:

- Guidelines on seed movement across provenance regions may need to be re-examined to include the movement of FRMs to areas where they may better suit the future climate.
- Breeding programmes for Mediterranean trees should focus on traits related to increased drought resistance but should also consider overall resilience to stochastic changes. This will require a significant shift in the Mediterranean tree-breeding paradigm.
- As the climate changes, forest health will be increasingly affected by new pathogens and pests, and breeding and the identification of natural resistance are needed urgently.
- Seed collection practices should ensure representative sampling of the genetic diversity by collecting from more than 30 trees per collected stand.

Forest management can favour evolution through natural selection by encouraging the emergence of new genotype combinations by mating unrelated trees or by avoiding counter-selection of fitness-related traits. Further research is required on the fitness value of traits that are selected for in silviculture (*e.g.* the extent to which juvenile vigour is associated with drought resistance). Forest management can also help maintain the evolutionary potential in stands by varying stand structure and density, maintaining connectivity between forest patches and accelerating rotations.

At the same time, conservation strategies need to be strengthened and the identification of ecologically marginal populations that may serve as sources of valuable adaptations encouraged. Although *ex situ* conservation may be the only alternative for species and provenances under extreme threat of extinction, dynamic *in situ* conservation networks should be preferred, particularly in the context of climate change (Koskela *et al.*, 2012). Indeed, it is *in situ* where adaptation is challenged by new environmental conditions, and it is thus *in situ* where evolutionary novelty is created via natural selection. The Mediterranean region is still underrepresented in the coordinated pan-European FGR conservation network developed by EUFORGEN (Koskela *et al.*, 2012; Lefèvre *et al.*, 2012). The same criteria and standards could efficiently be used to extend the conservation effort on FGRs to the entire Mediterranean region. It is also crucial that conservation networks cover the full range of environmental heterogeneity (including marginal stands of low production value), as well as the establishment of experimental plantations in new environments resembling those predicted in the near future by ecological models.

Where possible, habitat restoration using ecological engineering technologies should be promoted, especially in areas where human impact is highest, such as in the vicinity of large urban, industrial and agronomic centres. Such efforts should be strongly connected with gene conservation approaches to ensure that the adaptive value of the reproductive materials used is properly considered. Awareness-raising efforts should aim to ensure that the managers of habitat restoration projects understand the importance of selecting the most appropriate reproductive materials: a failure to use locally adapted and evolutionary resilient material will likely impair restoration projects. There might be a need for regulation, since many restoration projects do not currently fall within the reach of national forest laws and escape the need for FRM control.

Integration

In the rapidly evolving environmental, social and economic context, forest management objectives, decision-making tools and strategies need to be adapted to potential new conditions and new demands for forest goods and ecosystem services. For example, improving the water balance or creating appropriate stand structures that reduce the vulnerability of forests to climate-driven risks (*e.g.* fire and drought) might appear to be the most relevant management objectives in certain Mediterranean areas (FAO, 2010a). However, developing new management strategies adapted to climate change is not easy because of the underlying uncertainties in climate change projections, the incomplete understanding of tree responses to the changing climate, and the lack of knowledge and information on how forest management might affect the adaptation of forest ecosystems to the changing climate and related risks.

Adapting forest management to changing and uncertain conditions requires compromises between short-term and long-term objectives, for example between achieving mitigation today without increasing vulnerability and without counteracting selection for the future, and achieving selection today without eroding adaptive capacity in the future. Therefore, a major interdisciplinary research effort is needed to rethink current forest management objectives to address new demands (*e.g.* water versus biomass) and conditions (risks);

optimize forest management strategies based on an understanding of the genetic and physiological mechanisms underlying the response of tree species to climate change; and explore the effects of climate change on optimal management strategies for various objectives (*e.g.* profitability, water and biomass production) (Birot *et al.*, 2011). To support these research fields, the most recent emerging methodologies (*e.g.* in modelling and statistics) and tools (*e.g.* in genetics) should be used and collaboratively shared by the scientific community working on Mediterranean forests.

To support the development of adaptive forest management, new forest management decision-support tools (Muys *et al.*, 2010) are needed to integrate the following: dynamic forest simulation models based on genetic and physiological processes controlled by climatic and edaphic factors; optimization techniques that can aid in finding the optimal combination of management variables (*e.g.* thinning intensity and periodicity, and rotation length); and user-friendly interfaces that facilitate the selection of, for example, climate scenarios, management objectives, site variables and economic parameters, and provide visual and summarized information on optimal forest management strategies for the selected variables. One of the few examples of an operational decision-support tool for Mediterranean forests is Gotilwa+, developed as part of the European MOTIVE project, which supports forest management design for the optimal delivery of multiple ecosystem services under climate change.

Legal aspects should also be addressed. In times of economic constraint, most managers operating in a market-based economy will seek the cheapest solution, even when it may be suboptimal in other respects. Legal instruments, based on ecologically and genetically sound scientific findings, should set minimum requirements for forest practice.

Conclusion

Adaptive management is not only urgent for the Mediterranean forests themselves but also for regions that might experience a shift in climate towards a typically Mediterranean one in the future and which could benefit from Mediterranean FGRs. Action is needed now towards adaptation and the development of new forest practices. It is challenging because of the uncertainty. The state of the environment in 50–100 years cannot be predicted with any certainty, but the direction of change is clear. Thus, over the long term, adaptive strategies can be thought of in terms of trajectory. Innovative forest practices are required, and the challenge is to combine immediate-term and long-term objectives.

Experimenting with innovative forest practice takes time, and it is needed. In the short term, however, knowledge can be gained from uncontrolled specific situations, such as exceptional climatic events. For this, there is an urgent need to improve the documentation of the current situation of Mediterranean forests regarding climate change, such as long-term climatic data, vegetation maps and records of past silviculture (including of the origins of planted material). The lack of such documentation frequently limits the capacity for analysis in specific situations. If accurate assessment data were available, modelling could help to deal with uncertainty.

New research lines have been identified. Networking and collaboration with and beyond the scientific community working on Mediterranean forests should be encouraged. Knowledge transfer, expertise and innovation can only be achieved by building and fostering close links between science, policy, management and society.

Forest fire prevention under new climatic conditions

Forest fire regimes depend on many factors that change over time, such as weather, fuel load, type and condition, forest management practices, and socio-economic context. Changes to a forest fire regime can have significant impacts on natural resources and ecosystem stability, with consequent direct and indirect economic losses. On the other hand, active forest and fire management can help counteract the impacts of climate change.

Although most forest fires in the Mediterranean region are caused by human activity (*i.e.* have anthropogenic ignition sources) it has been shown that, for Mediterranean Europe, the total burnt area changes significantly from year to year, largely because of weather conditions (Camia and Amatulli, 2009). In many cases, extreme fire danger conditions in southeastern Europe leading to major wildfire events have been driven by an explosive mix of strong winds and extremely high temperatures, following prolonged periods of drought (San-Miguel-Ayanz, Moreno and Camia, 2012).

Climate is an important driver of wildfire potential over time (Flannigan, Stocks and Wotton, 2000), but recent studies (Pausas and Paula, 2012) have shown that, under Mediterranean climatic conditions, fuel structure (*i.e.* the amount and connectivity of burnable resources) is more important than the frequency of climatic conditions conducive to fire. Landscape features, such as vegetation and fuel characteristics, are also important in shaping current and future fire–climate relationships at a regional scale. Thus, future changes in fire regime might differ from what might be predicted by climate alone. Future modelling efforts should include landscape components in climate change scenarios to improve projections for the Mediterranean region.

Fire–climate relationship

Meteorologically based fire danger indices evaluate and summarize the fire danger on the basis of current and past weather. These indices, normally applied on a daily basis, can also provide seasonal summaries to compare the overall wildfire potential of a given year due to meteorological conditions. The Canadian Fire Weather Index System (FWI) (Stocks *et al.*, 1989; Van Wagner, 1987) has often been used for this purpose (San-Miguel-Ayanz *et al.*, 2003).

The FWI has six components to rate fuel moisture content and potential fire behaviour in a common fuel type (*e.g.* a mature pine stand) and in “no slope” conditions. Calculations are based on daily (12 noon) measurements of air temperature, relative humidity, wind speed and the amount of precipitation in the preceding 24 hours. The first three components of the FWI consist of numerical rating values of the moisture content of forest floor layers with differing drying rates and at various depths. Specifically, the Fine Fuel Moisture Code rates the moisture of litter and other dead fine fuels at the top of the surface fuel layer; the Duff Moisture Code rates the moisture of the loosely compacted organic layer at moderate depth; and the Drought Code represents the moisture content of the deep layer of compact organic matter. Each of these three moisture codes carry useful information, being indicators of ease of ignition and the flammability of fine fuels (the Fine Fuel Moisture Code); fuel consumption in medium-sized woody material and moderate duff layers (the Duff Moisture Code); and fuel consumption in large logs and amount of smouldering in deep duff layers (the Drought Code) (Alexander, 2008). The other three FWI codes are fire behaviour indices that score the expected rate of fire spread (initial spread index), the fuel available for combustion (build up index), and fire line intensity. FWI is the final index that combines the initial spread index and the build up index. An important aspect of the FWI System is that the output depends only on meteorological observations and does not consider differences in fuel type or topography, providing a uniform, relative way of rating fire danger through fuel moisture and fire behaviour potential (Van Wagner, 1987).

Camia and Amatulli (2009) tested the relationship of FWI System components against the monthly burnt area in part of the Mediterranean region (southern France, Italy, Greece, Portugal and Spain). Data were obtained from the EU Fire Database of EFFIS (years 1985 to 2004) and the corresponding FWI daily series was computed using the ERA-40 dataset, the 40 years re-analysis data archive of the European Centre for Medium Range Weather Forecast (Uppala *et al.*, 2005). Separate multiple regression analyses were made for the summer–autumn (May to November) and winter–spring (December to April) periods. Figure 4.5 shows the plot of interpolating surface of the model for the summer–autumn period, by far the most important in this context because it covers the entire main fire season of in the Mediterranean region.

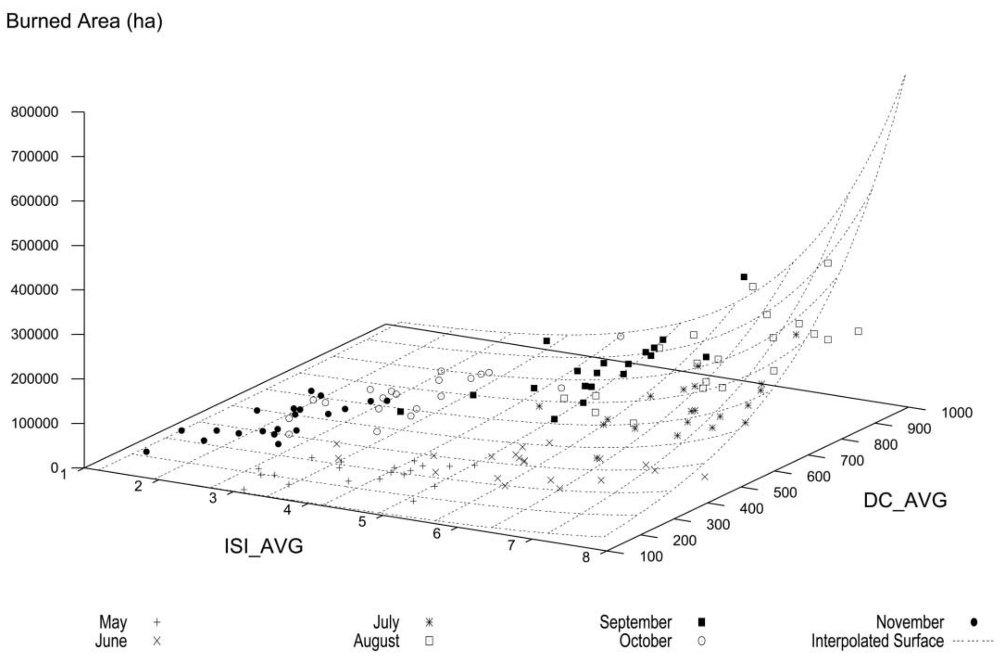

Figure 4.5. Monthly burnt area against initial spread index and Drought Code monthly averages in the European Mediterranean basin, May to November, 1985–2004, with interpolating surface
Source: Camia and Amatulli, 2009.

Modelling the effect of climate change on fire

Climate change projections suggest substantial warming and increases in the number of droughts, heat waves and dry spells across most of the Mediterranean region. Such climatic changes would increase the length and severity of the fire season, the area of forest at risk, and the probability of large fires, possibly leading to increased desertification. Regional climate model runs on the various emission scenarios of the IPCC allows the comparison of fire danger conditions, as assessed using the FWI System under current and projected future climates.

Modelling for Mediterranean Europe by Amatulli, Camia and San-Miguel (2013), a subregion comprising Portugal, Spain, Southern France, Italy and Greece for which a long time series of fire records and climate was available, suggests that climate change would lead to a marked increase in fire potential, with a projected increase of burnt area of 66 percent and 140 percent under the 2 x carbon dioxide and 3 x carbon dioxide scenarios, respectively. The doubling and tripling of the atmospheric concentration of carbon dioxide (compared with pre-industrial levels) is projected to occur approximately by the end of this century under the IPCC's B2 and A2 emission scenarios, respectively. These projections are subject to a number of uncertainties. For example, they do not take into account changes in fuel conditions (vegetation), ignitions or human activity (*e.g.* adaptation measures) that may influence the area subject to fire as well as the overall impacts of forest fire.

Fire prevention and adaptation options

Options for forest fire mitigation vary between countries and subregions, and there is no single comprehensive database of wildfire mitigation measures for the Mediterranean region. There is also significant variation in the funding available for wildfire mitigation among countries and subregions, and such funding is often scattered between institutions.

The adaptation of wildfire management strategies to a changing climate implies evaluating and implementing options and activities using an integrated approach. No single scheme is applicable, since the fire environment, socio-economic context and impacts of forest fire differ significantly between countries. Although quantitative data are unavailable, it is widely recognized that fire prevention is equally important to fire suppression and will remain so in the face of a changing climate. Even today, if little or no fire prevention has been carried out (*e.g.*, fire hazard reduction, fuel treatment, prescribed fires) in an area, suppression is unlikely to stop a catastrophic fire under extreme weather conditions. Fire exclusion policies are considered a risky option in the Mediterranean region and a better approach is integrated management that includes prescribed fuel-reduction burning.

Climate change will alter fire regimes, with projections of more frequent and more severe fire conditions. Altered fire regimes will, in turn, have an ecological impact that will affect forest composition and structure and biomass storage, with a feedback effect on the fire environment. Therefore, fire management strategies adapted to a changing climate should be integrated with forest management.

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