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The status of Mediterranean forests 2025

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Foreword

The forests and landscapes of the Mediterranean region are undergoing a period of profound transformation. Demographic expansion, changing land-use patterns, increasing climate extremes and rising social inequalities are exerting unprecedented pressure on natural ecosystems. At the same time, these landscapes play a pivotal role in supporting livelihoods, preserving biodiversity, and contributing to the global climate and sustainability agendas.

The 2025 edition of the status of Mediterranean forests (SoMF) marks a renewed commitment to understanding, managing and restoring these vital landscapes. Building on the foundations laid by the 2013 and 2018 reports, this edition provides a comprehensive and forward-looking assessment of the region's forests, drawing on updated data, regional cooperation and the experiences and insights of diverse stakeholders across the Mediterranean.

This year's report comes at a critical moment. The region is continuing to experience the cascading effects of climate change, wildfires and land degradation, compounded by social and economic vulnerabilities. Yet, there is also a clear momentum for change, evidenced by political declarations on forest and landscape restoration, the expansion of protected areas, innovative fire management strategies, and a growing recognition of the role that urban and peri-urban forests play in building resilience at the rural–urban interface.

The 2025 edition of the SoMF highlights the strategic designation of the Mediterranean as a United Nations World Restoration Flagship. This designation underscores the region's potential to serve as a global model of ecological restoration grounded in science, local knowledge and inclusive governance.

This work is the result of a collaborative effort organized by the Committee on Mediterranean Forestry Questions – *Silva Mediterranea*, in partnership with various institutions, networks and civil society actors committed to sustainable development. FAO would like to express its sincere gratitude to the contributors, partners and national correspondents who shared their expertise and data.

We hope this report will inform and inspire decision makers, practitioners, researchers and communities. The findings emphasize the need for decisive and coordinated action to reverse forest degradation, invest in long-term resilience, and recognize the value of Mediterranean forests not only as natural assets but also as a foundation for inclusive and sustainable societies.

On behalf of the FAO Forestry Division, I would like to reaffirm our commitment to supporting Mediterranean countries in advancing forest and landscape sustainability. Together, we can build a greener, more resilient and more equitable future for the Mediterranean region and beyond.

Mr Zhimin Wu
Director, Forestry Division
Food and Agriculture Organization of the United Nations

Contributors

Chapter 1

Constantin TSAKAS	Plan Bleu (United Nations Environment Programme Mediterranean Action Plan), Marseille, France
Giovanbattista de Dato	FAO, Rome, Italy

Chapter 2

Christophe Besacier	FAO, Rome, Italy
Valeria Contessa	FAO, Rome, Italy
Giovanbattista de Dato	FAO, Rome, Italy
Valentina Garavaglia	FAO, Rome, Italy
Erica Lupi	FAO, Rome, Italy
Anssi Pekkarinen	FAO, Rome, Italy
Satia Ras	FAO, Rome, Italy
Pedro Pablo Vivar Mulas	FAO, Rome, Italy

Chapter 3

Dimitrios N. Avtzis	Forest Research Institute, Hellenic Agricultural Organization Demeter, Athens, Greece
Andrea Battisti	University of Padua, Italy
Thomas Boivin	Ecology of Mediterranean Forests, National Research Institute for Agriculture, Food and Environment, Avignon, France
Magda Bou Dagher Kharrat	European Forest Institute, Barcelona, Spain
Manuela Branco	Forest Research Centre, School of Agriculture, University of Lisbon, Portugal
Maria Mercedes Caron	European Forest Institute, Barcelona, Spain
Pilar Fernandez-Conradi	Ecology of Mediterranean Forests, National Research Institute for Agriculture, Food and Environment, Avignon, France
Mustapha Gachi	National Institute of Forestry Research, Chéraga, Algeria
Maria J. Lombardero	Unit of Sustainable Environmental and Forest Management, University of Santiago de Compostela, Spain
Eduard Mauri	European Forest Institute, Barcelona, Spain
Zvi Mendel	Plant Protection Division, Agricultural Research Organisation, Bet Dagan, Israel
Pedro Naves	National Institute for Agricultural and Veterinary Research, Oeiras, Portugal
Nabil Nemer	Holy Spirit University of Kaslik, Lebanon
Pio Federico Roversi	CREA Research Centre for Plant Protection and Certification, Florence, Italy
Giuseppino Sabbatini-Peverieri	CREA Research Centre for Plant Protection and Certification, Florence, Italy
Shiroma Sathyapala	FAO, Rome, Italy

Chapter 4

Christophe Besacier	FAO, Rome, Italy
Diana Colomina	Forest Programme, WWF Spain, Madrid, Spain
Jordi Cortina-Segarra	Department of Ecology, and Multidisciplinary Institute for Environmental Studies, University of Alicante, Spain
Anne Maud Courtois	FAO, Rome, Italy
Giovanbattista de Dato	FAO, Rome, Italy
George Gann	Society for Ecological Restoration, Washington DC, United States of America
Valentina Garavaglia	FAO, Rome, Italy
Young Kim	FAO, Rome, Italy

Maria Melero	Forest Programme, WWF Spain, Madrid, Spain
Andrea Romero Montoya	FAO, Rome, Italy
Cristiane Sater Melnik	FAO, Rome, Italy
Alessandra Sensi	Union for the Mediterranean, Barcelona, Spain
Bethanie Walder	Society for Ecological Restoration, Washington DC, United States of America

Chapter 5

Laurent Alfonso	Union for the Mediterranean, Barcelona, Spain
Davide Ascoli	University of Turin, Italy
Valentina Bacciu	Institute for Bioeconomy, National Research Council, Sassari, Italy
Sahbi Bedhief	General Directorate of Forestry, Tunisia
İsmail Belen	United Nations Forum on Forests, New York, United States of America
Bastien Dieppois	Coventry University, United Kingdom of Great Britain and Northern Ireland
Jonathan Eden	Coventry University, United Kingdom of Great Britain and Northern Ireland
Carolina Gallo Granizo	FAO, Rome, Italy, and Coventry University, United Kingdom of Great Britain and Northern Ireland
Celia García Feced	Ministry for Ecological Transition and Demographic Challenge, Madrid, Spain
Johann Goldammer	Global Fire Monitoring Center, Fire Ecology Research Group, Max Planck Institute for Chemistry and Freiburg University, Mainz, Germany
Elen Hernández Paredes	Ministry for Ecological Transition and Demographic Challenge, Madrid, Spain
George Mitri	University of Balamand, Lebanon
Duarte Oom	FAO, Rome, Italy, and Joint Research Centre of the European Commission, Brussels, Belgium
Jesús San-Miguel-Ayanz	Joint Research Centre of the European Commission, Brussels, Belgium
Ümit Turhan	General Directorate of Forestry, Ankara, Türkiye

Chapter 6

Erdoğan Atmış	Institute for Environmental Studies (IVM), Vrije Universiteit Amsterdam, Kindom of the Netherlands
Simone Borelli	FAO, Rome, Italy
Federica Di Cagno	FAO, Rome, Italy
Pedro Calaza	Spanish Association of Public Parks and Gardens, Madrid, Spain
Paloma Cariñanos	University of Granada, Spain
Michela Conigliaro	FAO, Rome, Italy
Sara Di Lonardo	Research Institute on Terrestrial Ecosystems, National Research Council, Italy
Sondes Fkiri	National Research Institute of Rural Engineering, Water and Forests, Tunisia
Fabio Salbitano	University of Sassari, Italy
Giovanni Sanesi	University of Bari, Italy
Pierre Sicard	ACRI-ST, France
Dimitris Tsimplinas	Ministry of Environment, Energy and Climate Change, Athens, Greece
Urša Vilhar	Slovenian Forestry Institute, Ljubljana, Slovenia

Chapter 7

Dania Abdul Malak	European Topic Centre on Spatial Analysis and Synthesis, University of Málaga, Spain
Patricia Adame	Institute of Forest Science, National Institute for Agricultural Research and Technology, Madrid, Spain
Iciar Alberdi	Institute of Forest Science, National Institute for Agricultural Research and Technology, Madrid, Spain
Annemarie Bastrup-Birk	Forests and Environment, European Environmental Agency, Copenhagen, Denmark
Isabel Cañellas	Institute of Forest Science, National Institute for Agricultural Research and Technology, Madrid, Spain
Javier Chico	Ministry for Ecological Transition and Demographic Challenge, Madrid, Spain

Ana Isabel Marín	Department of Geography, and European Topic Centre on Spatial Analysis and Synthesis, University of Málaga, Spain
George Mitri	Land and Natural Resources Programme, Institute of the Environment, University of Balamand, Lebanon
Daniel Moreno	Institute of Forest Science, National Institute for Agricultural Research and Technology, Madrid, Spain
Lara Samaha	Department of Ecosystems, Ministry of Environment, Beirut, Lebanon
Antonio Sánchez	European Topic Centre on Spatial Analysis and Synthesis, University of Málaga, Spain
Nassima Yahi	Department of Ecology and Environment, University of Sciences and Technology Houari Boumediene, Algeria
Ouahid Zanndouche	Forest Ecosystem Sciences Division, National Forest Research Institute, Algeria

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Abbreviations

AI	artificial intelligence
AIFM	International Association for Mediterranean Forests
AECID	Spanish Agency for International Cooperation
AFD	French Development Agency
ARO	Agricultural Research Organisation
BTU	Bursa Technical University of Türkiye
CBAM	Carbon Border Adjustment Mechanism
CBD	Convention on Biological Diversity
CEAM	Centre for Environmental Studies in the Mediterranean
CFVA	Sardinia Forest Service (Italy)
CFWIS	Canadian Fire Weather Index System
COE	Collect Earth Online
CPMF	Collaborative Partnership on Mediterranean Forests
D4R	Diversity for Restoration
DG CLIMA	Directorate-General for Climate Action of the European Commission
DG ENV	Directorate-General for Environment of the European Commission
DG MENA	Directorate-General for the Middle East, North Africa and the Gulf of the European Commission
DG REGIO	Directorate-General for Regional and Urban Policy of the European Commission
DG RTD	Directorate-General for Research and Innovation of the European Commission
DPSIR	Drivers, Pressures, State, Impact and Response
EBRD	European Bank for Reconstruction and Development
EEA	European Environment Agency
EFFIS	European Forest Fire Information System
EFI	European Forest Institute
EFIMED	European Forest Institute Mediterranean Facility
EGFF	Expert Group on Forest Fires
EIB	European Investment Bank
EM	Eastern Mediterranean
EMC	Eastern Mediterranean country
ERDF	European Regional Development Fund
EU	European Union
EUR-OPA	European and Mediterranean Major Hazards Agreement
FAO	Food and Agriculture Organization of the United Nations
FERM	Framework for Ecosystem Restoration Monitoring
FFEM	French Facility for Global Environment
FISE	Forest information System for Europe
FLR	forest and landscape restoration
FRA	Forest Resources Assessment
FWI	Fire Weather Index
GBF	Kunming-Montreal Global Biodiversity Framework
GCF	Green Climate Fund
GCM	general circulation model
GDP	gross domestic product
GEF	Global Environmental Facility
GFMC	Global Fire Monitoring Center
GIS	geographic information system
GLAD	Global Land Analysis & Discovery
GNI	gross national income
GPFLR	Global Partnership on Forest and Landscape Restoration
GWFN	Global Wildland Fire Network
IKI	International Climate Initiative (Germany)
IMFN	International Model Forest Network
INAV	Institute for Agricultural and Veterinary
IPBES	Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
ITA	international tourist arrival
IUCN	International Union for Conservation of Nature
IUCN CEM	International Union for Conservation of Nature Commission on Ecosystem Management
IUCN-Med	International Union for Conservation of Nature Centre for Mediterranean Cooperation
IWFC	International Wildland Fire Conference
JRC	Joint Research Centre of the European Commission

LFMWB	Landscape Fire Management in the Western Balkans
LIFE	L'Instrument Financier pour l'Environnement
LMIC	low- and middle-income country
MAES	Mapping and Assessment of Ecosystems and their Services
MATE	Ministry of Environment and Land-Use Planning (Algeria)
MEA	Millennium Ecosystem Assessment
MedECC	Mediterranean Experts on Climate and Environmental Change
MEET	Mediterranean Experience Ecotourism Network
MENFRI	Mediterranean Network of Forest Research and Innovation
MITECO	Ministry for Ecological Transition and Demographic Challenge (Spain)
MMFN	Mediterranean Model Forest Network
MOAF	Ministry of Agriculture and Forestry (Türkiye)
NDC	nationally determined contribution
NENA	Near East and North Africa
NENFIRE	Near East Network on Wildlands Forest Fire
NFI	national forest inventory
NGO	non-governmental organization
OECD	Organisation for Economic Co-operation and Development
OGM	General Directorate of Forestry (Türkiye)
OSCE	Organization for Security and Cooperation in Europe
PRIMA	Partnership for Research and Innovation in the Mediterranean Area
RCM	regional climate model
RFMC	Regional Fire Monitoring Center
RFMRC	Regional Fire Management Resource Center
RSS	Remote Sensing Survey
SCBD	Secretariat of the Convention on Biological Diversity
SEMC	Southern and Eastern Mediterranean country
SER	Society for Ecological Restoration
SFMF	Strategic Framework on Mediterranean Forests
SM	Southern Mediterranean
SMC	Southern Mediterranean country
SMZ	strategic management zone (Spain)
SoEF	State of Europe's Forests
SoMF	State of Mediterranean Forests
SPIMS	Sustainable Planning Information Management System (Lebanon)
UfM	Union for the Mediterranean
TFEU	Treaty on the Functioning of the European Union
UCLG	World Organization of United Cities and Local Governments
UNCCD	United Nations Convention to Combat Desertification
UNCTAD	United Nations Conference on Trade and Development
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
UNEA	United Nations Environment Assembly
UNEP	United Nations Environment Programme
UNEP/MAP	Mediterranean Action Plan of the United Nations Environment Programme
UNFCC	United Nations Framework Convention on Climate Change
UNFF	United Nations Forum on Forests
URI	urban–rural interface
USGS	United States Geological Survey
WHO	World Health Organization
WITS	World Integrated Trade Solution
WM	Western Mediterranean
WMC	Western Mediterranean country
WMO	World Meteorological Organization
WWF	Worldwide Fund for Nature

Executive summary

The urgency of sustainable development

- The Mediterranean region faces mounting pressures from, among others, climate change and growing population that fuel persistent economic inequalities, particularly affecting youth and women.
- A sustainable transition is urgently needed—one that promotes low-carbon, inclusive economic growth while respecting ecological limits and promoting resilience.
- Strengthened regional cooperation, improved education systems, and comprehensive monitoring of the status of the Mediterranean region are vital to ensure a green and resilient future.

Forest trends at a glance

- Forests and other wooded lands in the Mediterranean region cover 28 percent of the region's land area, while croplands and grasslands dominate with 61 percent, highlighting the continued importance of integrated land-use strategies.
- Between 1990 and 2020, forest area in Mediterranean countries expanded by 12 percent, driven largely by gains in Western countries.
- Between 1990 and 2020, the expansion of the Western Mediterranean countries forest area slowed, with minimal net change in recent years.

Rising threats to forests

- Mediterranean forests are at risk: the Mediterranean region is warming faster than the global average, with severe consequences impacting forest resources, such as increased wildfires, prolonged droughts, shifting rainfall patterns, pest outbreaks and widespread land degradation.
- Land-use change in the Mediterranean region presents a contrasting picture: while urban expansion and agriculture are growing in the south, land abandonment and forest regrowth are more common in the north and east.
- Around 30 percent of the Mediterranean region is highly vulnerable to desertification, and invasive pests – introduced through trade and intensified by climate change – are increasingly damaging native forests.
- Urgent measures such as adaptive forest management, restoration of degraded land, integrated pest and fire strategies, and early warning systems are needed, supported by regional cooperation and localized responses.

Restoration gains momentum

- With 80 million hectares of land with restoration potential in the region, forest and landscape restoration is gaining traction across the Mediterranean, supported by strong political will and a shift towards inclusive, science-based practices.
- Between 2017 and 2022, it is estimated that 1.3 to 2.3 million hectares were put under restoration in the Mediterranean region by the nine countries that endorsed the Agadir Commitment.
- Forest and landscape restoration is increasingly recognized as more than tree planting, involving local communities, diverse species and traditional knowledge.
- The World Restoration Flagship, "Restoring Mediterranean Forests", recognized by the United Nations Decade on Ecosystem Restoration demonstrates that, with its longstanding experience in restoration and its unique forest resources, the Mediterranean region is uniquely positioned to support and scale up forest and landscape restoration efforts globally.
- Despite progress, many restoration projects in the Mediterranean region lack long-term vision or funding, ecological complexity and proper monitoring. New regional standards are being developed to offer tools for better planning and evaluation.
- To move forward, the Mediterranean region must secure sustainable financing, embed standards in national policies, engage

private investors, and promote community-led governance and restoration practices tailored to local contexts.

Confronting the fire crisis

- Wildfires are a growing threat to Mediterranean ecosystems, exacerbated by climate change and land-use changes.
- From 2010 to 2023, there were on average 1 590 fires per year in the Mediterranean biome, burning 395 000 hectares yearly.
- In the same period, Western Mediterranean countries and Algeria had the largest burnt areas with respect to the total Mediterranean ecosystem burnt area, and the highest number of fires.
- Forests and agricultural lands are the most affected by wildfires in the Mediterranean region, particularly sclerophyllous forests. Prevention through integrated planning, fuel management and community engagement is crucial.
- Post-fire restoration, including soil stabilization and reforestation, supports ecosystem recovery.
- Enhanced cooperation at regional and international levels – through data sharing, joint responses and knowledge exchange – is key to effective fire management.

Urban and peri-urban forests: a bridge between worlds

- By 2030, the Mediterranean region is expected to see a 160 percent increase in urban land cover.
- The urban–rural interface in the Mediterranean region is a dynamic zone of land-use change and demographic transformation. Urban and peri-urban forests also support social inclusion, recreation and alternative livelihoods such as ecotourism.
- Urban and peri-urban forests offer vital ecosystem services in this transition space, helping to regulate microclimates, sequester carbon, reduce wildfire risks and preserve biodiversity.
- Managing the urban–rural interface effectively requires governance models that reflect its unique socioecological context, engaging stakeholders from urban, peri-urban and rural areas in co-designed planning and management.

Why monitoring matters

- Understanding the complex relationship between people and Mediterranean forests requires integrated assessments that combine ecological, economic and social data.
- Strengthening long-term monitoring and enhancing data systems are essential to support more effective action. Monitoring efforts are often hampered by inconsistent classifications, methodological challenges and limited institutional capacity.
- The use of technologies such as artificial intelligence and remote sensing can enhance data collection and analysis.
- Fostering regional collaboration among stakeholders on monitoring forest resources, including with local communities, can strengthen forest governance and help track the effectiveness of sustainable forest management practices.

Introduction

The 2025 edition of the status of Mediterranean forests (SoMF 2025) presents a comprehensive overview of the status, trends and challenges facing forest ecosystems and forest-related livelihoods across the Mediterranean region. Building on previous editions, this volume aims to inform and support policy dialogue, regional cooperation and evidence-based decision-making to promote the sustainable management of Mediterranean forests in a time of accelerating environmental and socioeconomic change.

The Mediterranean basin hosts diverse forest and woodland ecosystems that deliver vital environmental services and sustain the livelihoods of millions. These landscapes are essential for biodiversity conservation, climate regulation, soil preservation, water supply and cultural identity. However, they are increasingly threatened by land degradation, climate change, wildfires, demographic shifts and economic changes.

The SoMF 2025 is framed by the ambition of contributing to the implementation of the United Nations 2030 Agenda for Sustainable Development and the FAO Strategic Framework, while also advancing the goals of regional initiatives such as the Committee on Mediterranean Forestry Questions – *Silva Mediterranea*. It responds to the urgent need for better data, shared knowledge and integrated approaches to managing Mediterranean forests as multifunctional and resilient socioecological systems.

This new edition aims to provide an overview of the current status of forest resources in the Mediterranean region, based on the most recent available statistics, and to showcase sound management, nature-based solutions and sustainable socioeconomic actions by reporting on case studies and good practices. The SoMF 2025 presents the potential of key approaches for tackling environmental crises in the Mediterranean region and building resilient Mediterranean forest ecosystems, by 1) restoring Mediterranean degraded lands; 2) Mediterranean forest fire management; 3) managing urban forests; and 4) monitoring Mediterranean forest resources.

This volume is structured around eight chapters:

- Chapter 1 provides a contextual overview of socioeconomic trends in the region, with attention to demographic patterns and economic development.
- Chapter 2 assesses the current state of forest resources and their dynamics.
- Chapter 3 reviews forest health and degradation, and the impacts of climate change.
- Chapter 4 explores the status, challenges and opportunities in forest and landscape restoration initiatives in the Mediterranean region.
- Chapter 5 reports on the current wildfire statistics in the Mediterranean region and the need for integrated fire management.
- Chapter 6 focuses on the emerging role of urban and peri-urban forests in the Mediterranean area for tackling the challenges deriving from climate change.
- Chapter 7 highlights the role of advanced long-term monitoring as a tool for effective sustainable forest management and restoration planning.
- Chapter 8 concludes with reflections on pathways for transition, highlighting the role of innovation, community participation and nature-based solutions.

The preparation of this report has been a collaborative effort involving experts, institutions and country representatives from across the Mediterranean area. It is intended as both a technical reference and a strategic tool for policymakers, practitioners, researchers and civil society actors committed to the protection and sustainable use of Mediterranean forests.

As the region continues to confront overlapping environmental and socioeconomic challenges, the SoMF 2025 calls for renewed ambition, stronger cooperation and integrated action to ensure that Mediterranean forests thrive for generations to come.

Chapter 1
Mediterranean economic development models: bridging the gaps in equity and environmental sustainability

Constantin Tsakas
Plan Bleu (Mediterranean Action Plan of the United Nations Environment Programme [UNEP/MAP]), Marseille, France
Giovanbattista de Dato
Food and Agriculture Organization of the United Nations, Rome, Italy

Overview

The Mediterranean region is at a crossroads, facing the dual challenge of achieving both economic development and environmental sustainability. Although various economic models have spurred growth in the region, they have not yet attained inclusiveness and resilience, resulting in gaps in social equity and ecological balance. Persistent demographic pressures, changing consumption patterns and unsustainable production processes are exacerbating environmental stresses and jeopardizing biodiversity and natural resources, including forests. At the same time, structural unemployment, income inequality and economic volatility pose significant challenges to inclusive development, particularly for youth and women. This chapter explores these pressing issues with a focus on the interconnectedness of economic and environmental policies in the Mediterranean region. It highlights the urgent need to transition to sustainable economic models that reconcile human development and ecological stewardship. The decisions that shape the region's future can have both direct and indirect effects on forests and biodiversity, emphasizing the connections between economic and societal choices and a healthy environment.

Socioeconomic drivers of environmental and development challenges in the Mediterranean region

The population of countries in the Mediterranean region has grown steadily in the last three decades, reaching 531.7 million in 2021, including an increase of nearly 20 million people in only three years, from 2018 to 2021 (Appendix Table A1.1).

Human-induced environmental pressures are exacerbated by unsustainable production and consumption patterns and, in the absence of more sustainable lifestyles, will be further increased by population growth. Shifting food consumption patterns towards non-traditional diets, along with increased affluence and tourism, have placed significant pressure on natural resources and ecosystems, leading to the overexploitation of water, land and energy resources, as well as to food loss and waste. The region operates at a substantial ecological deficit, using approximately 40 percent more renewable resources and ecosystem services than it can provide (UNEP/MAP and Plan Bleu, 2020). The growing population is contributing to unsustainable industrial and waste management practices and to environmental degradation.

Population growth has also led to increased coastal urbanization, with major cities, transport routes and industrial infrastructure concentrated along coastlines. These coastal areas, which make up less than 12 percent of the Mediterranean's land area, are home to around one-third of the region's population, leading to increased pollution and environmental degradation.

Recent trends in economic growth

In 2000–2010, gross domestic product (GDP) growth rates of Southern and Eastern Mediterranean countries (SEMCs) outpaced those of EU member states in the Mediterranean region. The overall dynamics shifted during the 2010s in the wake of the Arab Spring and the international financial crisis of 2008, with lower growth rates in all subregions. As a result, the Mediterranean region's GDP grew by just 0.2 percent per year between 2015 and 2020 (Appendix Table A1.2). The COVID-19 pandemic acted as an additional impediment, with an average annual growth rate in the region of 0.7 percent in 2020–2022.

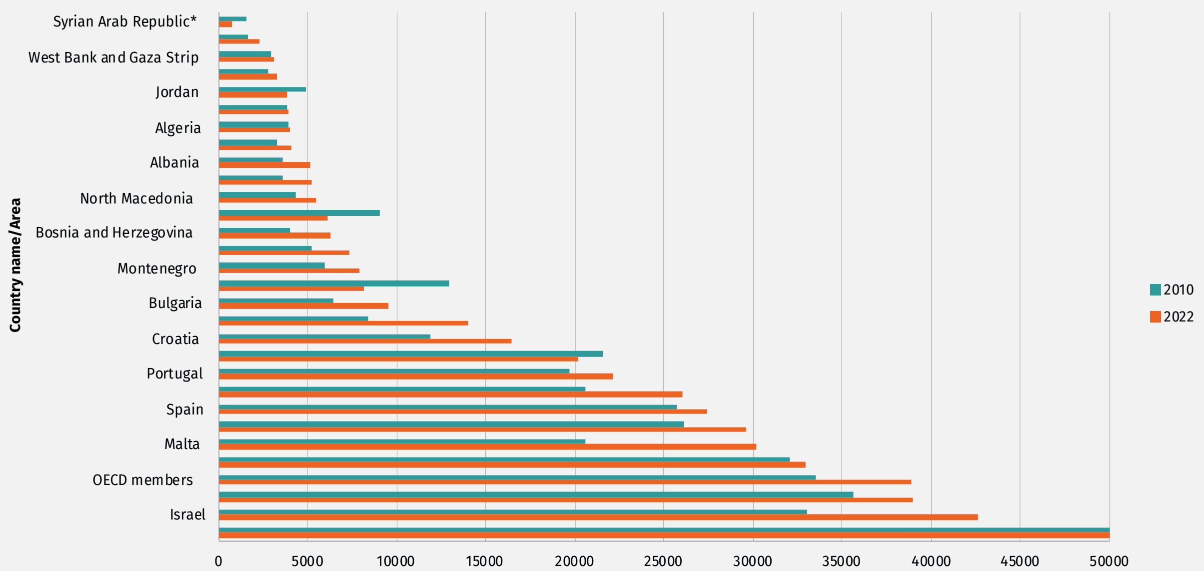
Figure 1.1 shows that GDP per capita differs considerably among Mediterranean countries, due largely to differences in political and societal stability. A lack of stability often impacts economies and standards of living. Figure 1.1 shows significant declines in GDP per capita between 2010 and 2022 in some countries, which can be attributed to political instability and conflicts and to an acute debt crisis that led to austerity measures and a contraction of economic activity.

Unemployment and labour-market participation

Unemployment trends

Although unemployment has long been a structural issue in the Mediterranean, a decreasing trend is evident: the average unemployment rate in the region was 13.5 percent in the 2000s but had dropped to 10.9 percent by 2022 (Table 1.1). Some subregions had markedly higher unemployment

Figure 1.1. Gross domestic product per capita in Mediterranean countries, 2010 and 2022



Source: World Bank Group. 2023. World Development Indicators: GDP per capita (constant 2015 USD). [Accessed on 1 September 2023]. https://databank.worldbank.org/source/world-development-indicators. Licence: CC-BY-4.0.

Table 1.1. Unemployment as a percentage of total labour force, Mediterranean countries/area, 2000–2022

	2000–2014	2015–2019	2020	2021	2022
Albania	15	14	13.1	12.7	11.8
Algeria	10.2	10.5	12.2	11.7	11.6
Bosnia and Herzegovina	27.6	21.5	15.3	14.9	14.1
Bulgaria	11.6	6.5	5.1	5.3	4.4
Croatia	15.2	11.1	7.5	7.6	6.7
Cyprus	11.6	10.9	7.6	7.5	7
Egypt	11.9	11	7.9	7.4	7
France	9.5	9.4	8	7.9	7.4
Greece	21.8	21.3	16.3	14.7	12.2
Israel	6.9	4.4	4.3	4.3	3.5
Italy	10.4	11.1	9.2	9.5	8.1
Jordan	12.4	16.3	19.2	18.4	17.9
Lebanon	7.8	10.2	13	12.5	12.6
Libya	19.4	19.5	20.3	20.6	20.7
Malta	6.3	4.3	4.4	3.5	2.8
Montenegro	19.4	16.3	17.9	16.9	15.4
Morocco	9.2	9.3	11.1	10.5	10.5
North Macedonia	30.7	22.4	16.6	15.8	15.1
Portugal	13.8	9.2	6.8	6.6	5.8
Serbia	21.5	13.9	9	10.1	9.5
Slovenia	8.8	6.6	5	4.7	4.2
Spain	23.3	17.7	15.5	14.8	13
Syrian Arab Republic	8.7	8.7	10	9.8	9.6
Tunisia	15.8	15.3	16.4	16.3	16.1
Türkiye	9.2	11.3	13.1	12	10
West Bank and Gaza Strip	19.7	24.8	25.9	26.4	25.7
Mediterranean average	14.5	13.0	12.0	11.6	10.9
Low and middle income	5.8	5.9	7	6.3	6.1
Lower-middle income	6.4	6.2	7.8	6.8	6.5

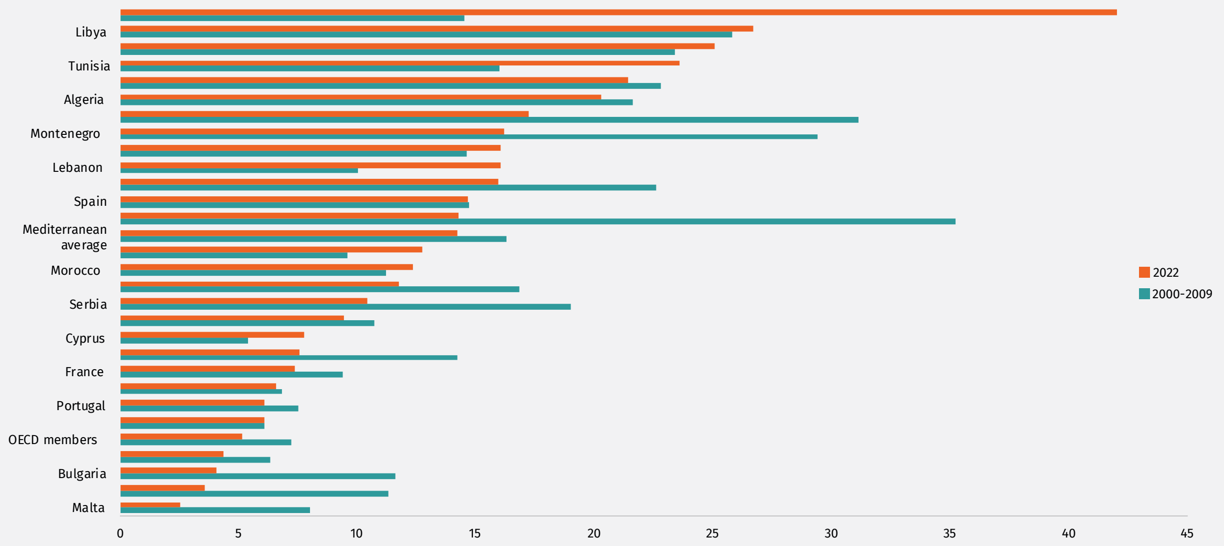
Source: World Bank Group. 2023. World Development Indicators: Unemployment, total, % of total labour force (modelled ILO estimate). [Accessed on 1 September 2023]. https://databank.worldbank.org/source/world-development-indicators. Licence: CC-BY-4.0.

rates than others in 2022,[1] notably in SEMCs, with country unemployment rates ranging from 16.1 percent to 25.7 percent. Among the European Mediterranean countries, the highest unemployment rates ranged between 15.4 percent and 14.1 percent in 2022. Moreover, as economic and social challenges worsen, it becomes increasingly difficult to create enough high-quality jobs, often leading to a brain drain including within European countries.

The number of people excluded from the economic system was very high in 2022, particularly among women and youth and especially in SEMCs. Female unemployment was more than double that in

[1] SEMCs: North Africa / Southern Mediterranean (Algeria, Egypt, Libya, Morocco, Tunisia) and Middle East / Eastern Mediterranean (Cyprus, Gaza Strip, Israel, Jordan, Lebanon, Syrian Arab Republic, Türkiye, West Bank); European Mediterranean countries: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, France, Greece, Italy, Malta, Montenegro, North Macedonia, Portugal, Serbia, Slovenia, Spain.

Figure 1.2. Unemployment, female, as a percentage of the female labour force, 2022 and 2000–2009



Source: World Bank Group. 2023. World Development Indicators: Unemployment, female, % of female labour force (modelled ILO estimate). [Accessed on 1 September 2023]. https://databank.worldbank.org/source/world-development-indicators. Licence: CC-BY-4.0.

low- and middle-income countries,[2] emphasizing ongoing challenges in creating equitable opportunities (Figure 1.2).

In addition to unemployment, the low female labour-force participation rate is a pressing issue (Appendix Table A1.3). Persistent gender disparities are inhibiting the full integration of women into the workforce.

Horizontal inequalities,[3] specifically in education, are also often perceived and resented by the population because of the disconnect between higher education and employment opportunities. Access to education has improved in SEMCs, but many graduates face persistent challenges in the school-to-work transition. This arises from an oversupply of graduates in certain fields, a lack of training in relevant skills, and a job market that fails to align with their qualifications. As a result, many educated young people are forced into low-paying or informal jobs, exacerbating youth unemployment and pushing many to emigrate in search of better prospects.

International data (World Bank Group, 2023a) show a modest decline in youth unemployment rates across the Mediterranean region, from an average of 27.8 percent in the 2000s to 24.9 percent in 2022. Southern and Eastern Mediterranean countries continued to have the highest youth unemployment rates in the region due to a range of structural challenges that often drive young people to emigrate out of necessity.

The informal sector plays a significant role in SEMCs, employing 45–80 percent of the population (Saoudi, 2022). Informal employment is most prevalent in the agriculture sector; it provides a social safety net for low-skilled workers and new entrants in the sector and serves as a shock absorber in times of crisis. It is also a cause of vulnerability, however, because most individuals employed informally lack social security and basic

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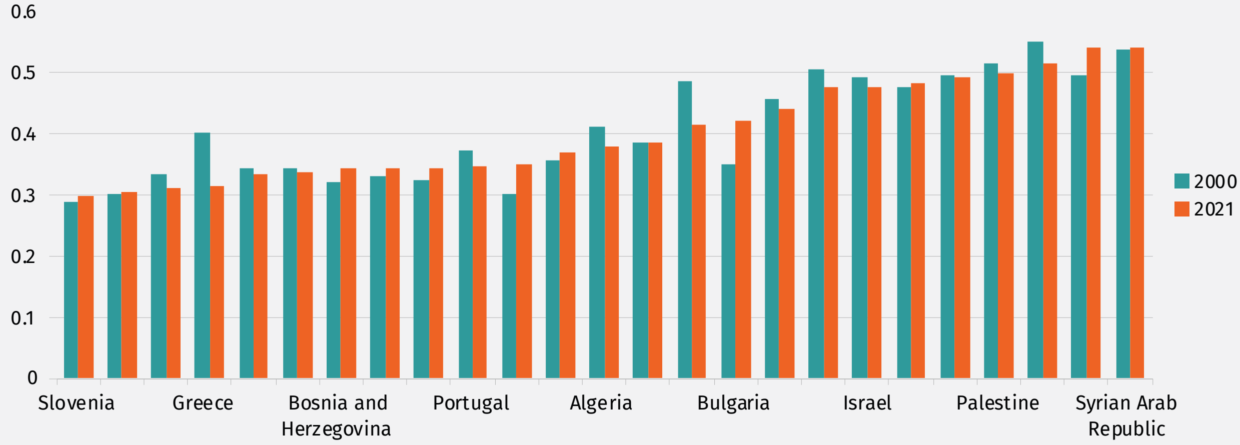
2 Low- and middle-income countries (LMICs) comprise all economies classified by the World Bank as:
- Low-income countries (LICs): gross national income (GNI) per capita of USD 1 135 or less (for the fiscal year FY26, based on 2024 data).
- Lower-middle-income countries: GNI per capita between USD 1 136 and USD 4 495.
- Upper-middle-income countries: GNI per capita between USD 4 496 and USD 13 935.
- Together, these three groups – low-, lower-middle- and upper-middle-income countries – are collectively referred to as LMICs. (For more information, see datahelpdesk.worldbank.org.).

3 Horizontal inequality refers to disparities among groups distinguished by identity-based characteristics (such as ethnicity, religion, gender or region) in access to resources, opportunities and outcomes, often arising from historical biases and social structures.

Figure 1.3. Percent share of national income held by the top 10 percent income group, 2000 and 2021



Source: World Inequality Database. 2023. Key indicators: Pre-tax national income share of top 10%. [Accessed on 1 September 2023]. https://wid.world/data/. Licence: CC-BY-4.0.

worker rights, and poor working conditions and a lack of vocational training limit prospects for long-term career development.

National income distribution efforts

Income inequality and other socioeconomic disparities are persistent challenges in the region (Figure 1.3) due to a complex interplay of historical, economic and structural factors. Data from the World Inequality Database show that, between 2000 and 2021, the share of national income captured by the top 10 percent of earners declined in some countries, with reductions ranging from 7.1 percent to 21.5 percent. Conversely, in other countries, this share increased – by as much as 20 percent – over the same period, pointing to diverging national trajectories in income distribution.

The Mediterranean region has one of lowest poverty rates of any region globally. According to recent data, it has a low headcount ratio at USD 2.15 per day (World Bank Group, 2023b), indicating that a larger proportion of the population than the global average is living above the poverty line. There has been a consistent decline in poverty since the turn of the century, with the poverty headcount ratio decreasing steadily from 1.6 percent in 2000–2010, to 1.2 percent in 2010–2014, to 1.1 percent in 2015–2019, to 0.5 percent in 2020 (note, however, that data for 2020 are incomplete for some countries). This trend has also been apparent in SEMCs, with some countries in that subregion exhibiting low poverty headcount ratios in 2015–2019 compared with the average for low- and middle-income countries (which is of 11.5 percent).

Nevertheless, the proportion of poor people in the region has increased significantly if assessed at a higher poverty threshold of USD 6.85 per day, reaching 12.5 percent of the population in 2015–2019 compared to only 1.1 percent when using the USD 2.15 threshold; thus, many people are living “on the brink of poverty”.

The potential for sustainable regional economic integration and diversification

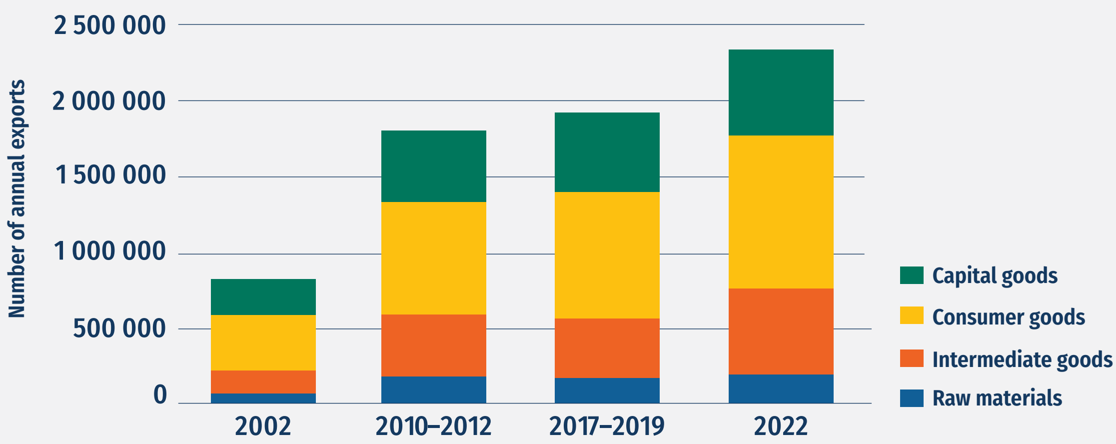
Industry and trade pressure on natural resources

Since the mid-1990s, economic integration primarily has taken the form of association agreements between the European Union and countries such as Algeria, Egypt, Israel, Jordan, Lebanon, Morocco and Tunisia, with provisions to promote economic, trade and financial collaboration. The goal has been to eventually establish a free-trade area between the European Union and Mediterranean countries, but this is yet to be realized.

The Mediterranean region primarily exports consumer goods; these comprised 43.4 percent of total exports in 2002 and 43.9 percent in 2022 (Figure 1.4). In 2022, intermediate goods accounted for 25.2 percent of total exports, highlighting the region's ability to provide value-added components for global supply chains. Note that the production of intermediate goods relies on inputs from various sectors and can place strain on natural resources, including forests. Capital goods in 2022 were in third place while raw materials, including forest products, ranked fourth, accounting for only 7 percent of total exports in 2022.

Thirty-six percent of SEMC exports were consumer goods in 2022, down from 39.3 percent in 2002 (Figure 1.5). Intermediate goods represented a large and growing share of exports, at 32.7 percent of total exports in 2022. Capital goods was the third-largest category, at 19.1 percent, followed by

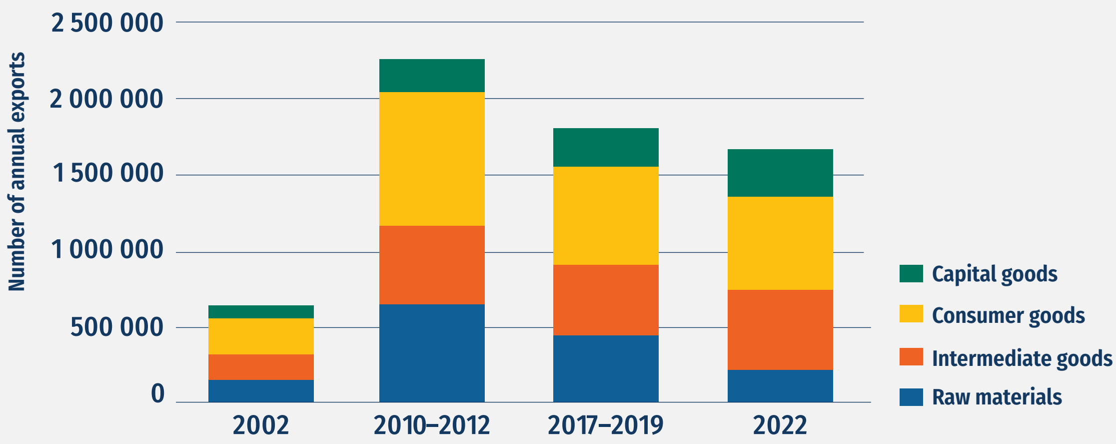
Figure 1.4. Total annual exports of the 27 Mediterranean countries by type of good, 2002–2022



Note: For external trade classifications, the 2002 version of the Harmonized System was used (HS 2002).

Source: Author's own calculations using World Bank. 2023. World Integrated Trade Solution (WITS). [Accessed in September 2023]. https://wits.worldbank.org/. Licence: CC-BY-4.0.

Figure 1.5. Total annual exports of Southern and Eastern Mediterranean countries, by type of good, 2002–2022



Note: The 2002 version of the Harmonized System (HS, 2002) was used for external trade classifications.

Source: Author's own calculations using World Bank. 2023. World Integrated Trade Solution (WITS). [Accessed in September 2023]. https://wits.worldbank.org/. Licence: CC-BY-4.0.

raw materials, at 12.2 percent. This relatively large proportion of raw materials in exports could have significant implications for the future of forests in SEMCs, potentially reducing their capacity to provide ecosystem services.

The trade in biodiversity-based products ("biotrade") is the collection, production, transformation and commercialization of goods and services derived from native biodiversity, including species and ecosystems, while meeting the principles of environmental, social and economic sustainability (UNCTAD, 2023). Analysing how the share of biotrade varies within total trade can provide insights into the relationship between economic activity and biodiversity conservation. Biotrade supports the transformation of supply chains towards more resilient models and the adoption of biodiversity-friendly practices, while still enabling them to comply with industry and market requirements.

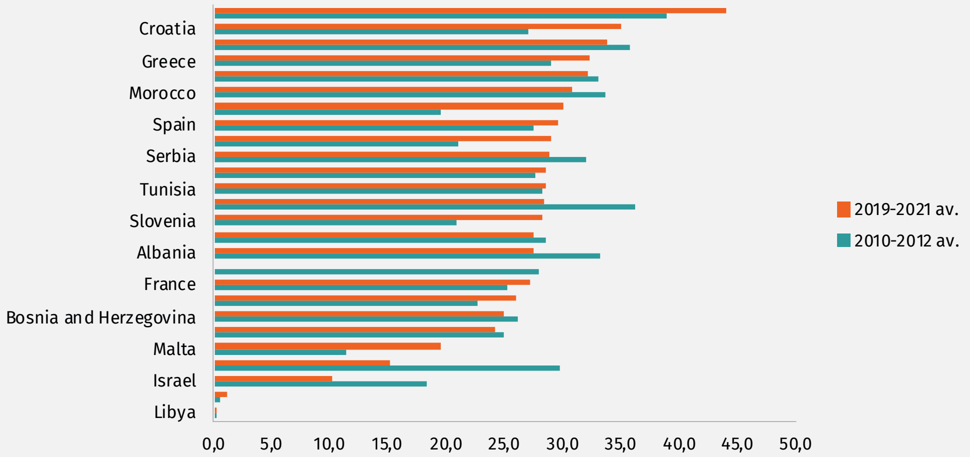
Biotrade made up a significant proportion (31–44 percent) of total trade in 2021 (Figure 1.6), with some countries showing gains of 7.4–10.5 percentage points between the periods 2010–2012 and 2019–2021. This is a potential indicator of successful efforts to promote sustainable practices, conservation, and the local production of goods and services derived from native biodiversity. However, the data also reveal declines in the share of biotrade in certain countries over the same period, underscoring uneven progress across the region.

European Union citizens and businesses are placing increasing emphasis on upholding social and environmental standards. This is expected to continue, compelling companies to re-assess their strategies for international production processes in multiple countries. A key factor that will be taken increasingly into account is distance travelled in global value chains; SEMCs, therefore, could emerge as crucial suppliers for EU businesses, provided their processes become "greener".

A shift from environmentally harmful "brown" products

The European Green Deal, which aims to make the European Union a fairer, more prosperous and more environmentally conscious society, was introduced in 2019. At its heart is an ambition to achieve net-zero greenhouse-gas emissions by 2050, thereby decoupling economic growth from resource use. To achieve this vision, the European Commission introduced the Fit-for-55 package – a set of policies, regulations and legislative tools – in 2021. The package includes the Carbon

Figure 1.6. Proportion of trade in biodiversity-based products as a percentage of total trade, 2019–2021 and 2010–2012 (averages)



Source: United Nations Conference on Trade and Development (UNCTAD) Data Hub. 2023. Trade and Biodiversity database (TraBio): Trade in biodiversity-based products. [Accessed on 1 September 2023]. https://unctadstat.unctad.org/EN/Biotrade.html

Border Adjustment Mechanism (CBAM), which is designed to address concerns related to carbon leakage and any misalignment with the European Union's climate ambitions among non-EU countries (including SEMCs). The aim of the CBAM is to ensure that imported goods have a carbon price comparable with that of goods produced domestically in the European Union. It is expected to affect products such as concrete, iron, steel, chemicals, fertilizers, industrial gases, aluminium and paper. Many SEMCs are heavily reliant on sectors with significant carbon emissions, making them vulnerable to the implications of the CBAM (Allianz Research, 2020). The European Union announced that a reporting system for CBAM-related products would commence in 2023, with financial adjustments for importers set to begin in 2026. As of 1 October 2023, the CBAM entered a transitional phase, requiring importers to report the greenhouse gas emissions of their imports without financial adjustments. This phase, running until 31 December 2025, allows for gradual implementation and adaptation by businesses.

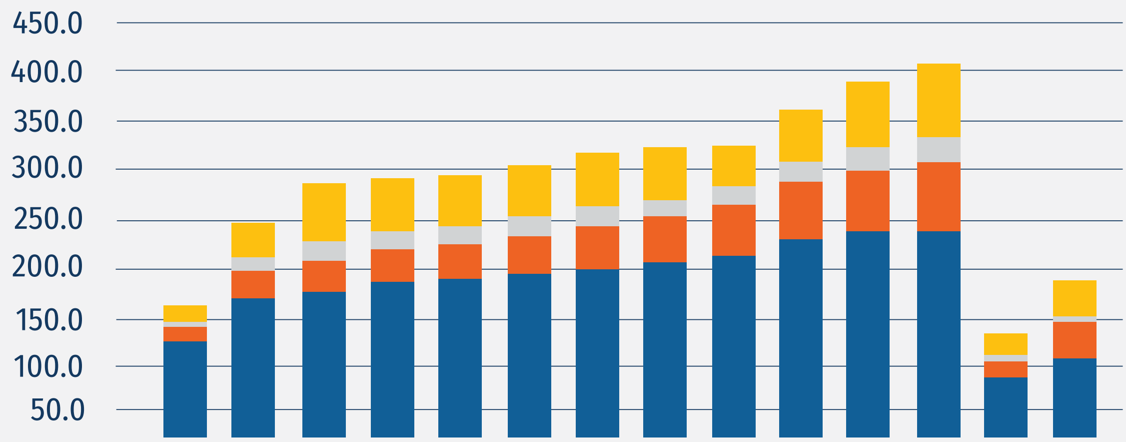
Several crucial issues require careful consideration in the context of the European Union–SEMC dialogue (Moreno-Dobson, Pariente-David and Tsakas, 2021). Southern and Eastern Mediterranean countries need to transition away from a reliance on environmentally detrimental "brown" products, and the introduction of the CBAM could present a strategic opportunity for them to make progress on this. The environmental transition will not happen overnight, however, and many SEMCs may be unable to decarbonize at the pace required to remain competitive in the EU market. The introduction of alternative energy technologies is a complex process for energy-intensive sectors. The long investment cycle means that today's assets must comply with emissions reduction targets for 2030 and 2040 (Eicke *et al.*, 2021), and many SEMCs will require technical and financial support from the European Union to do this.

Tourism and environmental stewardship

The Mediterranean is known for its exceptional natural resources, rich cultural heritages, diverse landscapes and advantageous geographic location, and it has become a top global tourist destination. International tourist arrivals (ITAs) surged sevenfold over a 5-decade period, from about 58 million in 1970 to 408 million in 2019 (just before the COVID-19 pandemic) (Figure 1.7).

The sector has suffered setbacks caused by the COVID-19 pandemic, however, with ITAs plummeting by more than two-thirds in 2020, followed by a modest recovery in 2021. There have been noticeable fluctuations in tourist arrivals in recent years due to various factors, including armed conflicts, security concerns, political instability and socioeconomic challenges. Economically, tourism wields substantial influence, contributing USD 943.4 billion to the region's GDP in 2019

Figure 1.7 International tourist arrivals in the Mediterranean region, 1995–2021



Source: UN World Tourism Organization. 2022. Tourism Statistics Database. [Accessed on 1 September 2023]. http://www.unwto.org/tourism-statistics/tourism-statistics-database and providing jobs for 18.4 million people. The pandemic had a drastic impact on the sector, halving its contribution to GDP and resulting in the loss of 3.1 million jobs.

The sector has led to or is exacerbating many pressing environmental challenges, but ecotourism provides a sustainable alternative by promoting responsible travel practices and encouraging tourists to appreciate and conserve the natural areas they visit. The Mediterranean Sea – 8.33 percent of which is designated as marine protected areas – is a hot spot for ecotourism, with 43 percent of tourists seeking out natural environments in the region. Initiatives like the Mediterranean Experience Ecotourism Network (MEET) and the DESTIMED PLUS project promote high-quality ecotourism experiences that benefit both conservation and local communities (Plan Bleu, 2022a). Expanding such initiatives is essential for ensuring that growth in the tourism sector does not lead to environmental degradation.

Investments for the low-carbon energy transition

The shift towards a low-carbon economy will create both opportunities and risks, with countries differing greatly in their capacity to manage the transition. The best-prepared countries for a low-carbon transition are those with minimal exposure to its impacts and a strong capacity to adapt swiftly and to take advantage of emerging opportunities. Peszko *et al.* (2020) suggested that the least-prepared countries face extreme vulnerability to external shocks resulting from the transition – most of these countries have endured prolonged conflicts that have devastated almost all non-oil tradable industries and undermined institutions.

The European Green Deal involves significant investments in renewable energy, particularly in Mediterranean countries that are part of the European Union. Massive investments will be directed towards solar, wind, hydroelectric and biomass energy, with two main objectives: to reduce reliance on fossil fuels for energy production; and to develop a resilient, low-carbon energy system that fosters sustainability. The aim of the Sustainable Europe Investment Plan is to mobilize EUR 1 trillion for sustainable investment over the next decade using the EU budget and associated instruments. The Green Deal's emphasis on green financing, exemplified by the establishment of a clear and detailed EU taxonomy, promotes both private and public investments in renewable energy projects.

The renewable energy sector in SEMCs offers key opportunities, particularly in solar energy. But financing energy infrastructure at the national and regional levels is a considerable challenge because of various risks in the region, such as political instability, inflation and existing inadequate infrastructure. The lack of bankability of renewable energy-source projects is a major obstacle and requires stronger risk management. An effective private sector could lead the transformation to sustainable economies, and SEMCs will need to establish policies, regulations and procedures conducive to this. The European Union could strengthen its work with SEMCs to address the challenges they face.

Enhanced international cooperation for sustainable socioeconomic models

Transitioning to a sustainable Mediterranean economy requires major shifts in production and consumption. It will involve promoting ecofriendly lifestyles and responsible resource use. Targeted policies, market incentives and accountability for product life cycles are essential. Transforming consumption and reducing demand for unsustainable goods also requires engaging youth, addressing inequalities and empowering women. Key actions include promoting sustainable fisheries, improving energy efficiency, advancing renewable energy, and ensuring accountable tourism governance (Demirel *et al.*, 2023; Plan Bleu, 2022b; Plan Bleu and UNEP/MAP, 2024). Regional vulnerabilities hinder progress towards sustainability, however, and there is a clear need for stronger international cooperation. Mediterranean countries will need to work together on key challenges to promote sustainable economic models, including forest conservation, restoration and sustainable use.

Financial resources and achievements in EU–Mediterranean regional cooperation have been limited to date. In February 2021, the European Commission proposed a new agenda for the Mediterranean, focusing on five key policy areas: (1) human development; (2) resilience; (3) peace and security; (4) migration; and (5) the green transition. The agenda emphasizes regional, subregional and interregional cooperation. Several flagship projects have been proposed across various sectors with the aim of enhancing collaboration and integration. There is growing emphasis on South–South cooperation, including beyond the Mediterranean, focusing on areas such as transport networks, renewable energy, and reducing emissions from maritime transport.

The region would benefit from the development of a comprehensive portfolio of bankable green and blue projects (that include ecological metrics) with potentially sufficient financial returns and positive environmental, sustainability and social impacts to attract funding from sustainability-oriented donors. The portfolio could also include initiatives focused on forest restoration, allowing funding and support to be channelled towards afforestation, reforestation, forest sustainable management and forest conservation. To achieve this, it is essential that the dialogue between the European Union and SEMCs is strengthened to address the challenges and to seize the opportunities presented by a sustainable green transition. Other actors, such as FAO, the Mediterranean Action Plan of the United Nations Environment Programme (UNEP/MAP) and the Union for the Mediterranean (UfM), can serve as platforms for facilitating this dialogue through high-level summits, ministerial meetings and thematic workshops, which could potentially lead to firm commitments and projects.

The European Union's experience with its own sustainability transition makes clear that the transition to a sustainable economic development model and the development of relevant projects are processes that require time as well as careful planning and coordination. At the same time, SEMCs should recognize the opportunity before them. By shifting away from "brown" sectors, they can establish themselves as hubs for green(er) innovation, attracting investment, creating new jobs – especially for young people – and fostering economic growth while also contributing to global sustainability goals.

Recent events have shown that supply chains are highly vulnerable to geopolitical instability. Enhanced international cooperation should facilitate the development of resilient supply chains and the strategic stockpiling of resources to ensure a steady flow of essential goods. Augier *et al.* (2022) highlighted a pressing need to enhance food production in SEMCs. A more integrated approach, coupled with collaboration between SEMCs and Mediterranean countries that are members of the European Union, can elevate industrial capabilities in the region. Among other things, Mediterranean countries could further develop agricultural models that address food security, environmental constraints (e.g. water scarcity) and the need for inclusive growth. In addition, in any future political agreements towards deeper trade integration between the European Union and the Mediterranean region, consideration could be given to the inclusion of binding clauses and provisions to protect the environment, including provisions to safeguard forest ecosystems.

Enhancing educational systems to be more focused on sustainability and responsive to the needs of the economy is crucial for creating jobs in the green and blue sectors. Mediterranean countries could consider working more closely together to improve the quality of vocational education and training with a view to enhancing skills that align with the needs of export sectors (Aboushady and Zaki, 2021). This could be done at the regional level by strengthening partnerships among businesses, government agencies and academia. The aim would be to improve the provision of green and blue skills, including those related to sustainable tourism and forest conservation, restoration and sustainable use, through on-the-job training, high-quality apprenticeships and other means. More effort is needed to close the gender gap by leveraging labour reforms as opportunities to promote social cohesion.

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Chapter 1 appendix

Table A1.1 Key demographic data, 2021

Countries	Median age of population (years)	Population change (thousands)*	Population density (number of persons/km²)	Total population (thousands)	Population, % change 2021/2001	Total net-migration (thousands)†	Life expectancy at birth (years)
Albania	37.27	-13.71	104.19	2,854.71	-9.5	-10.61	76.46
Algeria	27.80	731.25	18.55	44 177.97	41.6	-18.80	76.38
Bosnia and Herzegovina	41.82	-49.80	63.89	3 270.94	-22.0	-25.87	75.30
Bulgaria	43.73	-37.93	72.64	4 060.14	-9.9	-10.40	77.58
Croatia	37.59	5.78	134.65	1 244.19	29.0	2.00	81.20
Cyprus	23.94	1 741.26	109.76	109 262.18	50.0	-32.37	70.22
Egypt	41.59	58.20	117.04	64 531.44	9.3	20.61	82.50
France	44.74	-71.51	79.85	10 445.37	-5.7	-14.81	80.11
Greece	29.04	141.35	411.22	8 900.06	42.7	16.86	82.26
Israel	46.83	-241.86	200.15	59 240.33	3.9	28.02	82.85
Italy	28.27	-77.39	546.69	5 592.63	27.4	-115.12	75.05
Jordan	26.27	78.84	4.02	6 735.28	27.7	-0.70	71.91
Lebanon	39.01	11.25	1 672.22	526.75	31.0	10.41	83.78
Libya	54.52	-0.25	24 621.48	36.69	13.1	0.21	85.95
Malta	38.19	-0.69	45.46	627.86	-0.8	-0.10	76.34
Monaco	28.67	375.77	83.08	37 076.59	28.2	-46.24	74.04
Montenegro	43.20	0.76	105.24	2 119.41	6.9	4.57	80.69
Morocco	43.88	178.55	94.53	47 486.94	15.9	275.02	83.01
North Macedonia	19.21	113.15	852.72	5 133.39	58.9	-12.37	73.47
Portugal	20.94	530.44	116.08	21 324.37	27.5	212.19	72.06
Serbia	31.74	91.50	78.90	12 262.95	22.7	-9.19	73.77
Slovenia	30.93	632.46	110.15	84 775.40	30.3	-69.73	76.03
TOTAL MEDITERRANEAN				**531 685.56**	24.3		

Notes: * Difference between the population sizes on 1 January of 2021 and 2020.

† Net number of migrants, that is, the number of immigrants minus the number of emigrants.

Source: Author's own calculations from: United Nations DESA, Population Division. 2022. Un Population Division Data Portal: World Population Prospects 2022 Revision. [Accessed on 1 September 2023]. https://population.un.org/dataportal/home?df=e8cf3665-1a72-456e-a032-842b2a006e1c

Table A1.2. Average annual growth rate of gross domestic product expressed as a percentage

Countries	2000–2010	2010–2015	2015–2020	2020–2022
Albania	7.2	1.9	2.0	4.5
Algeria	4.6	3.5	0.3	1.7
Bosnia and Herzegovina	4.2	1.6	2.1	3.7
Bulgaria	5.7	1.4	1.7	3.8
Croatia	2.9	-0.2	0.8	6.5
Cyprus	3.9	-1.6	4.0	3.3
Egypt	6.1	2.8	5.0	1.6
France	1.3	1.0	-0.2	3.4
Greece	1.9	-3.7	-1.0	4.2
Israel	3.7	4.1	3.2	4.3
Italy	0.3	-0.7	-1.0	3.5
Jordan	8.3	2.9	1.3	1.1
Lebanon	7.5	2.1	-5.3	-3.5
Libya	4.6	-8.4	-2.4	15.7
Malta	2.7	6.0	3.8	5.9
Monaco	2.0	6.6	-0.3	10.8
Montenegro	3.8	1.9	0.0	6.5
Morocco	6.2	4.3	0.8	4.0
North Macedonia	3.4	2.6	0.9	2.8
Portugal	0.8	-0.8	0.5	2.8
Serbia	5.8	0.9	2.8	3.8
Slovenia	3.1	0.4	2.4	4.1
Spain	2.3	0.0	-0.4	2.8
Syrian Arab Republic	6.5	-10.4	-1.7	-50.0
Tunisia	5.0	1.8	-0.3	2.2
Türkiye	4.8	8.1	3.5	5.7
West Bank and Gaza Strip	5.6	5.2	0.1	3.5
Mediterranean	1.9	0.5	0.2	0.7
Low and middle income	8.5	5.8	3.7	3.6
Lower-middle income	7.5	5.4	3.4	3.0
OECD members	1.8	1.9	0.8	2.7

Source: Author's own calculations based on: World Bank Group. 2023. World Development Indicators: GDP per capita (constant 2015 USD). [Accessed on 1 September 2023]. https://databank.worldbank.org/source/world-development-indicators. Licence: CC-BY-4.0.

Table A1.3. Labour force participation rate, female (as a percentage of the female population, ages 15+)

Countries	2000-2010	2010–2014	2015–2019	2020	2021	2022
Albania	47.5	47.1	50.1	49.6	51.7	52.3
Algeria	13.1	15.2	16.5	15.4	15.9	16.4
Bosnia and Herzegovina	30.8	34.3	35.5	36.0	39.6	39.4
Bulgaria	46.2	48.0	49.1	49.2	49.0	50.3
Croatia	44.2	45.3	45.7	44.6	45.7	46.4
Cyprus	53.3	57.3	57.0	56.4	57.6	58.2
Egypt	20.8	22.9	20.4	14.5	14.6	15.1
France	50.2	51.5	51.4	50.6	52.2	52.5
Greece	41.8	44.1	44.8	43.8	43.9	44.8
Israel	55.0	58.0	59.4	58.2	59.4	60.2
Italy	37.6	39.2	40.7	39.8	40.1	41.0
Jordan	12.4	13.7	14.7	14.9	14.5	14.7
Lebanon	20.8	24.1	27.7	26.6	27.8	28.7
Libya	32.9	33.9	34.1	33.0	33.8	34.4
Malta	30.1	37.9	46.5	52.0	52.8	54.5
Montenegro	42.6	43.6	48.2	46.5	48.4	49.7
Morocco	25.5	24.9	23.3	22.0	20.7	21.4
North Macedonia	42.6	43.6	43.3	43.7	42.9	43.4
Portugal	54.8	54.6	54.1	53.6	53.8	54.7
Serbia	45.3	42.3	45.7	46.5	48.0	48.5
Slovenia	52.4	52.3	52.9	53.2	54.1	54.6
Spain	45.3	52.5	52.3	51.1	52.6	52.9
Syrian Arab Republic	17.0	14.8	16.2	16.0	16.4	16.8
Tunisia	24.1	25.4	26.4	25.1	25.7	26.2
Türkiye	24.9	28.9	33.1	30.8	32.8	34.2
West Bank and Gaza Strip	12.9	15.7	17.8	16.4	17.5	18.7
Mediterranean average	35.5	37.4	38.7	38.1	38.9	39.6
Low and middle income	49.5	47.4	46.1	44.4	45.6	45.8
Lower-middle income	36.6	35.2	33.1	32.6	32.9	33.4
OECD members	50.0	51.2	52.1	51.3	52.1	52.8

Source: World Bank Group. 2023. World Development Indicators: Labour force participation rate, female, (% of female population ages 15+) (national estimate). [Accessed on 1 September 2023]. https://databank.worldbank.org/source/world-development-indicators. Licence: CC-BY-4.0.

Chapter 2
Forest resources in the Mediterranean region

Giovanbattista de Dato, Valentina Garavaglia, Satia Ras, Christophe Besacier, Erica Lupi, Valeria Contessa, Pedro Pablo Vivar Mulas, Anssi Pekkarinen

Food and Agriculture Organization of the United Nations, Rome, Italy

Introduction

The Global Forest Resources Assessment

Since 1948, FAO's Gobal Forest Resources Assessment (FRA) programme has been conducting evaluations of the extent, condition, management and use of the world's forest resources. The assessments compile comprehensive country reports every 5 years to provide evidence for the decisions made by civil society, the private sector, governments and international conventions. Moreover, FRA facilitates data collection and reporting for Sustainable Development Goal Indicator 15.1.1, which measures forest area as a percentage of total land area, and Indicator 15.2.1, which tracks progress towards sustainable forest management. It oversees the custodianship of Indicator 15.4.2, which includes a) the Mountain Green Cover Index, and b) the proportion of degraded mountain land.

Since 1990, FAO has complemented the country reporting process with FRA remote sensing surveys, which assess the status and changes in tree cover and land use using satellite imagery. The FRA remote sensing surveys build the capacities of countries to use advanced remote sensing tools for producing independent and thorough analyses of forest area and forest area change, and their underlying drivers over time, at global, regional and biome levels.

Between 2024 and 2025, FAO will be undertaking a second participatory global Remote Sensing Survey (RSS) to obtain up-to-date, reliable and consistent estimates of forest area and forest area change at the regional, global and global ecological zone levels up to the year 2024.

The Global Forest Resources Assessment Remote Sensing Survey in the Mediterranean region

This chapter discusses forest resources in Mediterranean countries, drawing on the FRA 2020 country reports and the preliminary results of the FRA 2025 RSS for the Mediterranean pilot region.

The FRA country reports are prepared by officially nominated national correspondents and are based on official national data. The FRA RSS provides complementary estimates at the regional, ecological zone and global levels, which are derived from the work of remote sensing focal points in each country, appointed by the FRA national correspondents.

Definition of the study area and forest variables

This chapter discusses the area of forest and other wooded land in Mediterranean countries. The list of countries with their respective forest and other wooded land areas is presented in Table 2.1.

In FAO's forest classification system, "forest" is land spanning more than 0.5 hectares (ha), with trees higher than 5 metres (m) and a canopy cover of more than 10 percent, or trees able to reach these thresholds *in situ*. It does not include land predominantly under agricultural or urban land use (FAO, 2023).

"Other wooded land" refers to land that does not meet the criteria for classification as "forest" but still features some trees and woody vegetation. More specifically, FAO defines other wooded land as land spanning more than 0.5 ha; with trees higher than 5 m and a canopy cover of 5–10 percent, or trees able to reach these thresholds *in situ*; or with a combined cover of shrubs, bushes and trees above 10 percent. It does not include land that is predominantly under agricultural or urban land use (FAO, 2023). Examples of "other wooded land" are shrublands (e.g. garrigue), dominated by shrubs and bushes, or areas with scattered trees.

Many Mediterranean countries also include areas that do not have a typical Mediterranean climate. For example, France, Italy and Türkiye have substantial temperate areas, while many southern countries have large deserts.

Consequently, to estimate the extent of Mediterranean forests within specific ecological zones, we have used the preliminary results of the RSS 2025.

This chapter also analyses the net change in forest area. Forest area net change is calculated as the difference between the area that is deforested and the area of forest expansion between two FRA reference years (FAO, 2023), with the following definitions:

- Afforestation is the establishment of forest through planting or deliberate seeding, or both, on land that, until then, was not defined as forest.
- Natural expansion is the transformation of non-forest areas into areas with a forest use.
- Deforestation is the conversion of forest to another land use or the long-term reduction of the tree canopy cover below the minimum 10 percent threshold.

Growing stock is the stem volume over bark of all living trees, including the living trees that are laying, with a minimum diameter of 10 centimetres (cm) at breast height, or above buttresses if these are higher (FAO, 2023). It includes the stem from ground level up to a top diameter of 0 cm, excluding branches, twigs, foliage, flower seeds and roots.

Biomass stock can be divided into three components (FAO, 2023). The above-ground biomass is the amount of living vegetation, both woody and herbaceous, above the soil, including stems, stumps, branches, bark, seeds and foliage. The below-ground biomass is the biomass of live roots, excluding fine roots of less than 2 millimetres in diameter. Deadwood biomass is the non-living woody biomass that includes wood lying on the ground, dead roots and stumps larger than or equal to 10 cm in diameter or any other diameter used by the reporting country; it does not include litter.

The carbon stock is the amount of carbon stored in forest ecosystems, including the biomass (above-ground and below-ground), deadwood, litter and soil carbon pools. Here, we refer to the carbon stock above-ground, below-ground and in deadwood.

Along with conducting analyses at the global regional level, we also examined the data at the subregional level, categorizing the countries as Western Mediterranean, Eastern Mediterranean and Southern Mediterranean, as shown in Figure 2.1.

It should be noted that not all variables were provided to FAO by all countries across the entire analysis period; in those instances where data are missing or unavailable, the estimates likely constitute an undercount of the true values.

Forest and other wooded land area and area change

This section presents the data at the country level as published in the FAO FRA country reports 2020.

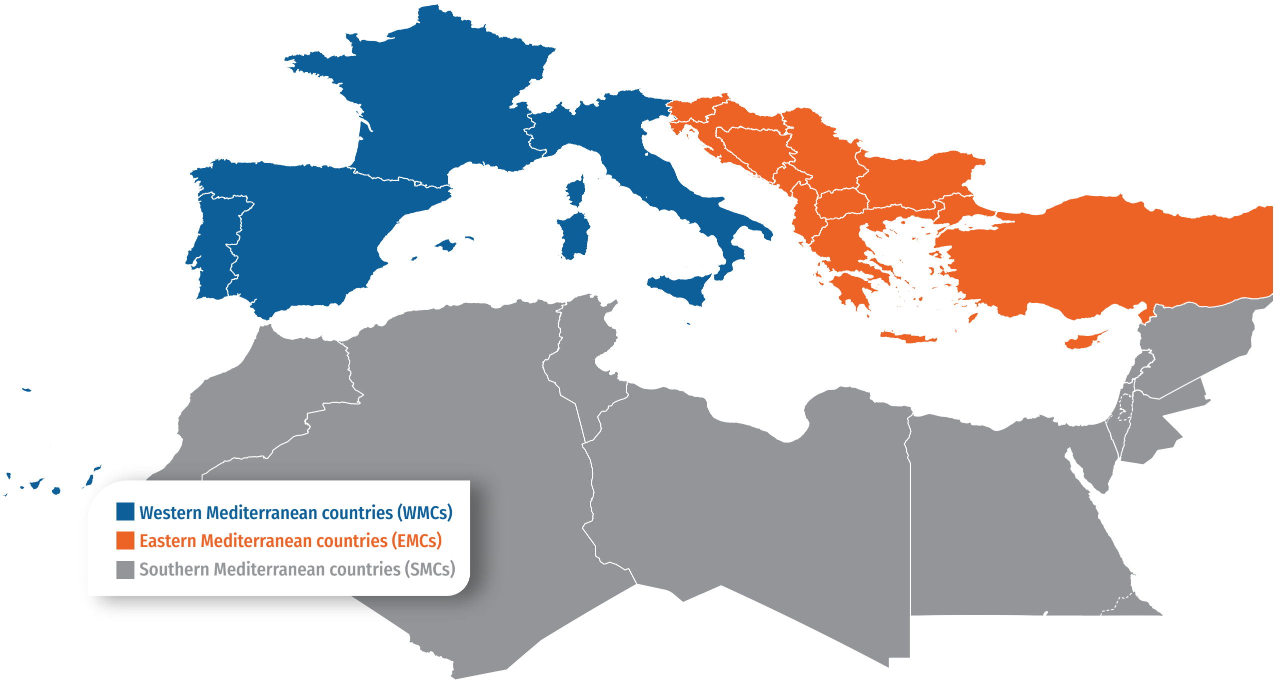
Forest area

According to FAO's definition of forests, Mediterranean countries had an estimated forest area of 99.2 million ha in 2020 (Figure 2.2, Table 2.1).

The forest area in the region increased from 84.6 million ha in 1990 to 99.2 million ha in 2020, therefore, by approximately 14.6 million ha, representing an average rate of increase of 0.6 percent per year over the 30-year period.

This rate of increase, however, varied over the period: looking 10-year time spans, it more than halved from around 0.7 percent in 1990–2000 and 2000–2010, to 0.3 percent in 2010–2020.

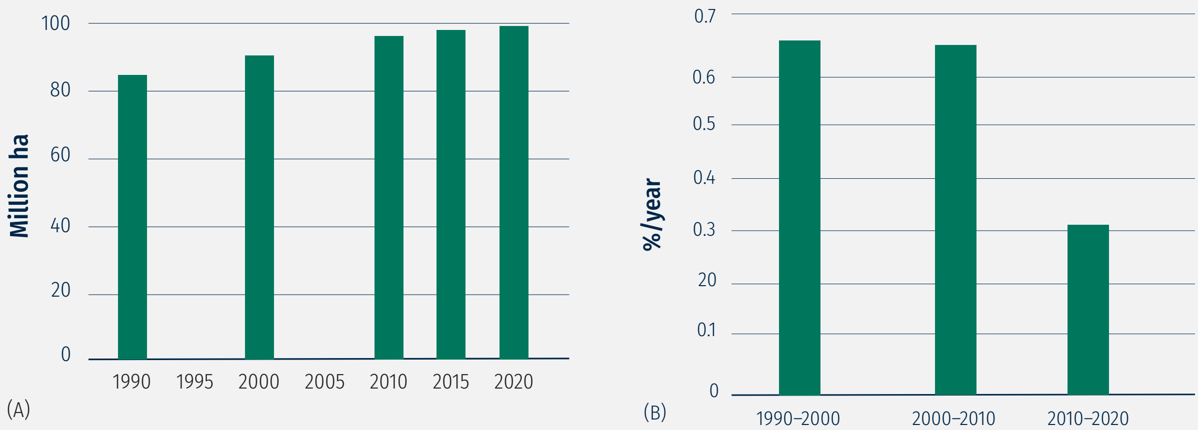
Figure 2.1. Eastern, Western and Southern Mediterranean subregions used in Chapter 2



Notes: Western Mediterranean countries (WMCs): France, Italy, Malta, Monaco, Portugal, San Marino and Spain; Eastern Mediterranean countries (EMCs): Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Greece, Montenegro, North Macedonia, Serbia, Slovenia and Türkiye; Southern Mediterranean countries: Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Palestine, Syrian Arab Republic and Tunisia.
Refer to the disclaimer on page ii for the names and boundaries used in this map.

Source: United Nations Geospatial. 2020. Map geodata [shapefiles]. New York, USA, United Nations.

Figure 2.2. (a) Forest area, 1990–2020, and (b) annual rate of forest area change over a moving period of 10 years. Data on this variable were provided to FAO by all 28 Mediterranean countries considered in the analysis



On average, 76 percent of the forest area at the country level consisted of naturally regenerating forest, while 24 percent was made up of planted forest. The categorization at the subregional level showed that in WMCs and EMCs, naturally regenerating forest accounted for 82 percent and 93 percent of the forest area, while planted forest represented 18 percent and 7 percent, respectively; in SMCs, the forest area was 55 percent naturally regenerating forest and 45 percent planted forest.

In 2020, approximately 25 percent, (24.9 million ha), of the forest area was within protected areas, an increase of 21 percent compared to 2010. Almost all forest in protected areas was in WMCs (61 percent) and in EMCs (37 percent).

Based on a biogeographic and bioclimatic definition, Mediterranean forests fall within three main ecological zones: subtropical dry forest, subtropical steppe and subtropical mountain system (FAO and JRC, 2012). By applying the

Table 2.1. Forest area, forest area as a percentage of national land area and of total forest area in the region, forest area annual net change in 2015–2020, area of other wooded land, and forest area within the subtropical climate domain, in Mediterranean countries

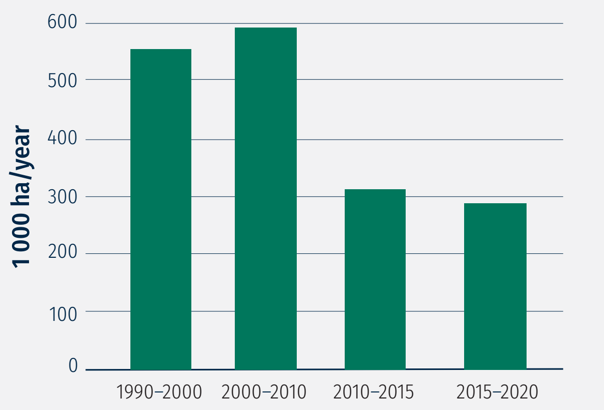
Countries	FRA 2020 total forest area (1 000 ha)	Forest area as a percentage of total land area, 2020 (%)	Forest area as a percentage of regional forest area, 2020 (%)	Forest area annual net change, 2015–2020 (1 000 ha/year)	FRA 2020 other wooded land area (1 000 ha)	FRA 2020 forest area in the subtropical domain (1 000 ha)	FRA 2020 country area in the subtropical domain (%)
Albania	788.90	28.79	0.80	-0.1	262.97	473.34	60
Algeria	1 949.00	0.82	1.97	-1.4	2 590.00	1 949.00	100
Bosnia and Herzegovina	2 187.91	42.73	2.21	5.5	625.37	131.27	6
Bulgaria	3 893.00	35.86	3.93	12.0	24.02	77.86	2
Croatia	1 939.11	34.65	1.96	3.4	618.09	232.69	12
Cyprus	172.53	18.67	0.17	0.0	213.57	172.53	100
Egypt	44.98	0.05	0.05	-0.7	0.00	36.88	82
France	17 253.00	31.51	17.40	83.4	843.00	2 242.89	13
Greece	3 901.80	30.27	3.93	0.0	2 634.72	3 472.60	89
Israel	140.00	6.47	0.14	-5.0	70.00	138.60	99
Italy	9 566.13	32.52	9.65	53.8	1 865.84	6 504.97	68
Jordan	97.50	1.10	0.10	0.0	51.00	97.50	100
Lebanon	143.33	14.01	0.14	0.6	170.16	143.33	100
Libya	217.00	0.12	0.22	0.0	330.00	217.00	100
Malta	0.46	1.44	0.00	0.0	0.07	0.46	100
Monaco	0	0	0	0.0	0	0	100
Montenegro	827.00	61.49	0.83	0.0	137.00	264.64	32
Morocco	5 742.49	12.87	5.79	11.6	1 223.70	5 742.49	100
North Macedonia	1 001.49	39.71	1.01	1.4	143.00	410.61	41
Palestine	10.14	1.68	0.01	0.0	0.00	4.66	46
Portugal	3 312.00	36.15	3.34	0.0	1 543.00	2 417.76	73
San Marino	1.00	16.67	0.00	0.0	0.00	1.00	100
Serbia	2 722.65	31.13	2.75	0.6	508.23	0.00	0
Slovenia	1 237.83	61.46	1.25	-2.0	27.42	61.89	5
Spain	18 572.17	37.17	18.73	4.2	9 381.82	1 2629.08	68
Syrian Arab Republic	522.08	2.84	0.53	0.0	35.43	522.08	100
Tunisia	702.73	4.52	0.71	1.5	307.77	702.73	100
Türkiye	22 220.36	28.87	22.41	118.0	712.64	19 553.92	88
TOTAL	**99 166.59**		**100.00**		**24 318.82**	**58 202.79**	

percentage of total subtropical climatic domain for each country as reported in the FRA 2020 (Table 2.1), the total Mediterranean forest area in 2020 was estimated at 58.2 million ha, which is equivalent to 59 percent of the total forest land use in the region.

The forest area net change (Figure 2.3) dropped by about half between 1990 and 2020, from 556 700 ha/year to 286 900 ha/year. This decrease is due to a 60 percent decrease in forest expansion from the maximum value of 452 000 ha/year observed in 2010–2015, and to a concurrent deforestation drop by 75 percent relative to the peak average value of 98 500 ha/year in 2010–2015.

At the subregional level, forest area increased in all the subregions (Figure 2.4). In WMCs, which accounted for 49.1 percent of the total forest area – compared with 41.2 percent and 9.6 percent for EMCs and SMCs, respectively – the average rate of forest area change was almost double (0.8 percent) that in the other two subregions (0.4 percent and 0.3 percent in EMCs and SMCs, respectively). In WMCs, the rate of forest area change decreased continuously from 1.2 percent in 1990 to 0.3 percent in 2020; in EMCs and SMCs, it peaked in 2000–2010, at 0.57 percent for the former and 0.67 percent for the latter, from a starting point of 0.24 percent in EMCs and 0.06 percent in SMCs in 1990–2000, and finally declining in the latter period to 0.37 percent in EMCs and 0.1 percent in SMCs.

Figure 2.3. Forest area net change, which is the difference between forest expansion and deforestation. Data on this variable were provided by 13 countries



The annual net change in forest area at the subregional level (Figure 2.5) decreased in WMCs from 470 000 ha/year in the first reporting period, 1990–2000, to 141 000 ha/year in the last reporting period considered, 2015–2020.

In EMCs, the forest area net change, which was 88 000 ha/year in 1990–2000, peaked in 2000–2010 at around 211 000 ha/year; it then decreased to 150 000 ha/year in 2010–2015 and to 139 000 ha/year in 2015–2000. In SMCs, the net change was less pronounced: from a negative value of -2 000 ha/year in 1990–2000, it peaked at 59 000 ha/year in 2000–2010 before decreasing to 17 000 ha/year in 2010–2015 and 7 000 ha/year in 2015–2020.

Area of other wooded land

In 2020, other wooded lands covered 24 million ha. The total area covered by forests and other wooded lands in the Mediterranean countries was 123.5 million ha (Table 2.1), which is approximately 14.1 percent of the total land area of those countries.

Figure 2.4. Forest area at the subregional level, 1990–2020, and annual rate of change over a moving period of 10 years. Data on this variable were provided by all 28 Mediterranean countries considered in the analysis

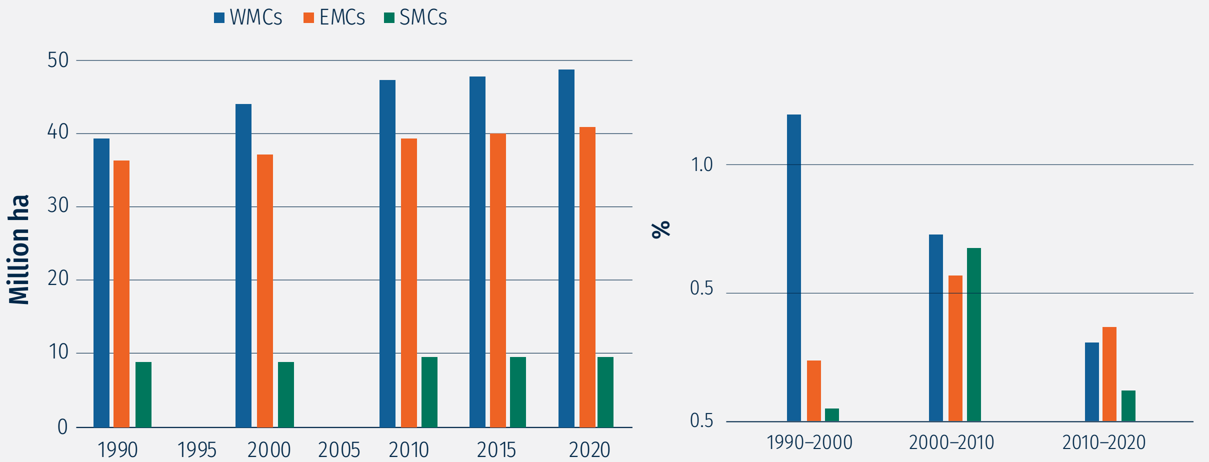
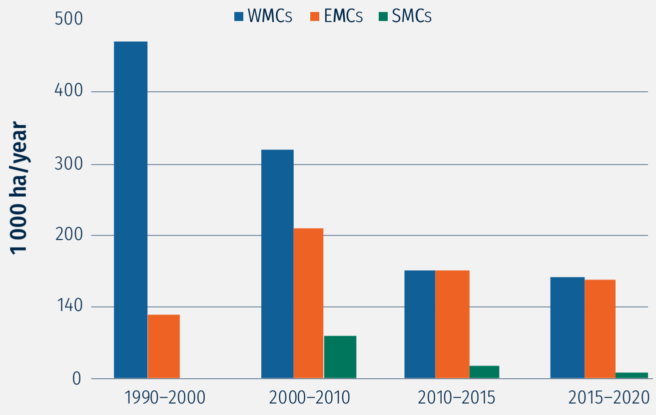


Figure 2.5. Forest area net change in the three Mediterranean subregions, 1990–2020 (data on this variable were provided by 13 countries)



Between 1990 and 2020, the area of other wooded land decreased by 2.5 million ha at an average rate of 0.3 percent/year. However, the decadal rate of change in other wooded land area for the 2010–2020 period was positive (about +0.3 percent), compared to the rates for 1990–2000 and 2000–2010, which were approximately negative at -0.4 percent and -0.8 percent, respectively (Figure 2.6).

At the subregional level, the most significant change in other wooded land area (Figure 2.7) was observed in WMCs, which also account for the greatest share of the total area of this land use at 56 percent: the decadal rate of change increased from around -1.1 percent in 1990–2000 to +0.3 percent in 2010–2020. In EMCs and SMCs, which account for 24 percent and 20 percent of the total other wooded land area, respectively, the decadal rate of change was more variable, ranging from 0.7 percent to 0.2 percent for EMCs and from 0.6 percent to 0.3 percent for SMCs, with both subregions exhibiting the same temporal dynamic with a minimum change rate during the second decade studied, 2000–2010.

Growing stock

This section presents the data at the country level as published in the FAO FRA 2020 country reports.

It is important to note the relatively low availability of data on growing stock for some countries and the sketchiness of the time series.

In 2020, growing stock in Mediterranean forests was 10.5 billion cubic metres (m^3) (Table 2.2 and Table 2.1).

From 1990 to 2020, growing stock in Mediterranean forests increased by 130 million m^3, which corresponds to an annual growth rate of 2 percent per year over the 30-year period. This annual rate dropped from an average of 2.1 percent per year during the 1990–2010 period to approximately 0.9 percent per year in the last decade, 2010–2020.

Figure 2.6. Area of other wooded land, 1990–2000, and annual rate of change over a moving period of 10 years (data on this variable were provided by all 28 Mediterranean countries considered in the analysis)

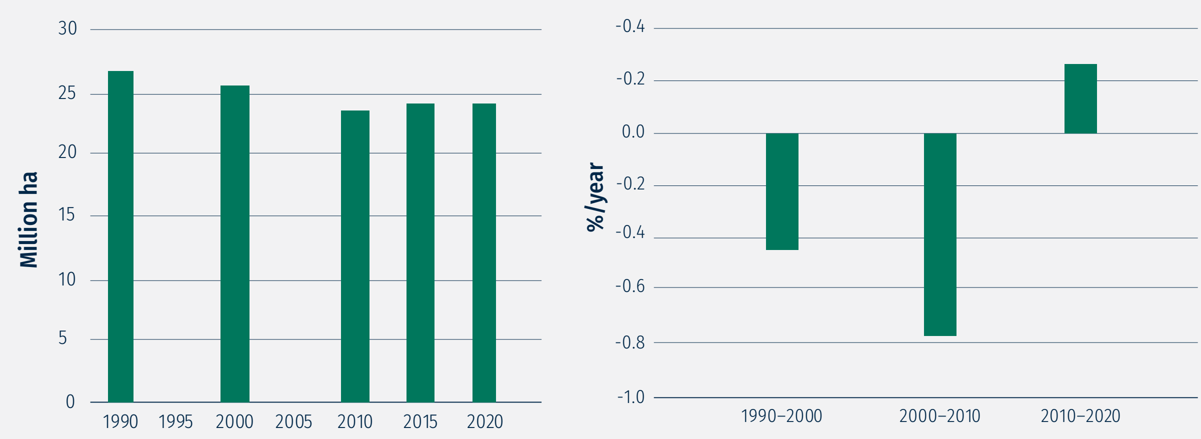


Figure 2.7. Area of other wooded land at the subregional level, 1990–2020, and annual rate of change over a moving period of 10 years (data on this variable were provided to FAO by all 28 Mediterranean countries considered in the analysis)

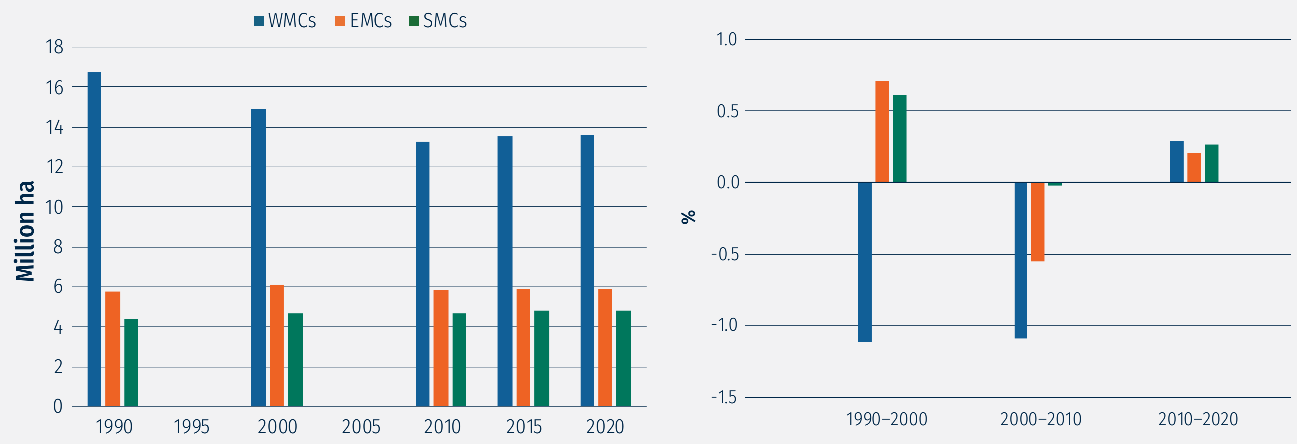


Table 2.2. Forest growing stock, 1990–2020

Countries	Forest growing stock (million m³)				
	1990	2000	2010	2015	2020
Albania	75.25	75.82	76.50	55.25	54.93
Algeria	74.31	70.45	85.75	89.00	87.14
Bosnia and Herzegovina	291.00	358.00	389.31	399.66	404.72
Bulgaria	405.89	526.50	646.50	680.36	766.92
Croatia	310.34	360.13	409.90	414.94	427.22
Cyprus	7.40	7.93	9.92	11.22	12.05
Egypt	5.26	0.11	7.88	5.81	5.40
France	2 077.41	2 254.28	2 648.61	2 855.81	3 055.83
Greece	161.79	176.32	191.83	191.83	191.83
Israel	0.39	0.39	0.51	0.53	n.a.
Italy	846.26	1 058.71	1 277.47	1 384.34	1 424.40
Jordan	2.93	2.93	2.93	2.93	2.93
Lebanon	4.98	4.92	4.90	5.00	5.11
Libya	7.87	7.87	7.87	7.87	7.87
Malta	n.a.	n.a.	n.a.	n.a.	n.a.
Monaco	0	0	0	0	0
Montenegro	72.60	72.60	121.40	121.00	121.40
Morocco	128.96	142.43	150.22	151.63	153.41
North Macedonia	76.29	78.89	76.41	76.41	76.41
Palestine	n.a.	n.a.	n.a.	n.a.	n.a.
Portugal	n.a.	n.a.	170.40	171.06	n.a.
San Marino	0.11	0.13	0.14	0.15	0.15
Serbia	235.00	250.00	415.47	418.61	420.91
Slovenia	273.24	332.91	406.12	414.82	414.18
Spain	560.18	906.05	1 035.34	1 059.45	1 108.85
Syrian Arab Republic	11.18	12.98	14.79	15.69	15.69
Tunisia	17.23	20.30	23.02	23.60	21.95
Türkiye	873.37	1 167.22	1 380.14	1 611.77	1 697.06
All countries	**6 519.24**	**7 887.87**	**9 553.33**	**10 168.74**	**10 476.36**

Note: n.a.: not available.

Forest biomass and carbon stock

Forest biomass in the Mediterranean region steadily increased over the 30-year period (Table 2.3). Between 1990 and 2020, above-ground biomass increased from approximately 1 443 tonnes per hectare (t/ha) to 2 121 t/ha, representing a 47 percent increase (1.6 percent/year), while below-ground biomass rose from 381 t/ha to 542 t/ha, representing a 42 percent increase (1.4 percent/year). The amount of deadwood biomass more than doubled, from 56 t/ha to 127 t/ha. However, there are numerous data gaps at the country level. This increasing trend in forest biomass reflects both the expansion in forest area and a growth in volume, highlighting the growing carbon sink potential of Mediterranean forests.

According to data from FRA 2020, the Mediterranean region stored 1 010 t carbon/ha above-ground. The increment compared to 1990 was 48 percent, representing a rate of increase of 1.6 percent per year (Table 2.4). A similar trend was observed for below-ground carbon, with a 43 percent increase over the total period, at 1.4 percent per year.

Considering the above-ground and below-ground pools, the total forest carbon stock in 2020 was 1 268 t carbon/ha. There are many gaps in the data available for deadwood (Table 2.4). Similarly, data are lacking for the litter and soil compartment (not shown).

Table 2.3. Forest biomass in Mediterranean countries in three different compartments (above-ground, below-ground and deadwood), 1990, 2010 and 2020

	Above-ground biomass (t/ha)			Below-ground biomass (t/ha)			Deadwood (t/ha)		
Countries	1990	2010	2020	1990	2010	2020	1990	2010	2020
Albania	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Algeria	26.06	29.38	29.39	10.69	10.71	10.71	n.a.	n.a.	n.a.
Bosnia and Herzegovina	n.a.	156.36	156.37	n.a.	32.63	32.64	n.a.	n.a.	n.a.
Bulgaria	108.46	157.63	180.50	27.7	37.69	42.98	n.a.	n.a.	n.a.
Croatia	170.5	168.60	174.01	40.55	39.91	41.21	n.a.	n.a.	n.a.
Cyprus	27.58	34.44	41.93	7.72	9.64	11.74	n.a.	n.a.	n.a.
Egypt	120	120.00	120.00	34.2	34.20	34.20	n.a.	n.a.	n.a.
France	109.5	124.00	135.50	31.20	35.50	38.60	n.a.	16.70	16.90
Greece	34.16	34.24	34.24	11.68	11.70	11.70	n.a.	n.a.	n.a.
Israel	7.6	7.50	7.69	1.9	1.80	1.80	0.08	0.08	0.08
Italy	84.5	105.30	110.60	20.8	26.00	27.30	4.7	6.00	6.20
Jordan	56.9	56.90	56.90	15.93	15.93	15.93	n.a.	n.a.	n.a.
Lebanon	60.93	61.27	61.27	13.58	13.65	13.65	n.a.	n.a.	n.a.
Libya	49.26	49.26	49.26	10	10.00	10.00	8.39	8.39	8.39
Malta	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Monaco	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Montenegro	n.a.	96.87	96.87	n.a.	15.99	15.99	n.a.	8.31	8.31
Morocco	33.52	39.23	39.89	10.03	11.94	12.25	0.21	0.21	0.21
North Macedonia	77.64	74.33	71.64	20.94	20.05	19.32	n.a.	n.a.	n.a.
Palestine	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Portugal	n.a.	41.03	40.91	n.a.	11.74	11.82	n.a.	0.92	0.90
San Marino	66.37	86.45	90.99	18.92	24.64	25.93	n.a.	n.a.	n.a.
Serbia	102.94	154.80	156.99	24.23	36.77	37.02	36.3	70.30	71.16
Slovenia	173.98	246.35	253.10	38.72	54.83	56.33	6.4	9.54	12.44
Spain	n.a.	53.49	55.87	n.a.	21.94	22.83	n.a.	n.a.	2.22
Syrian Arab Republic	49.99	49.99	49.98	15.02	15.02	15.02	n.a.	n.a.	n.a.
Tunisia	49.09	62.73	58.74	16.95	17.94	19.76	n.a.	n.a.	n.a.
Türkiye	33.63	41.57	48.11	9.94	11.95	13.06	0.34	0.42	0.48
All countries	**1 442.61**	**2 051.72**	**2 120.75**	**380.70**	**522.17**	**541.79**	**56.42**	**120.87**	**127.29**

Notes: Numbers in red are for 2015; n.a.: not available.

Table 2.4. Carbon stocks in the forests of Mediterranean countries in three different pools (above-ground, below-ground and deadwood), 1990, 2010 and 2020

	Above-ground biomass (t/ha)			Below-ground biomass (t/ha)			Deadwood (t/ha)		
Countries	**1990**	**2010**	**2020**	**1990**	**2010**	**2020**	**1990**	**2010**	**2020**
Albania	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Algeria	13.66	13.8	13.8	5.02	5.0	5.0	n.a.	n.a.	n.a.
Bosnia and Herzegovina	n.a.	73.5	73.5	n.a.	15.3	15.3	n.a.	n.a.	n.a.
Bulgaria	50.98	74.1	84.8	13.02	17.7	20.2	n.a.	n.a.	n.a.
Croatia	80.13	79.2	81.8	19.06	18.8	19.4	n.a.	n.a.	n.a.
Cyprus	12.96	16.2	19.7	3.63	4.5	5.5	n.a.	n.a.	n.a.
Egypt	56.4	56.4	56.4	16.07	16.1	16.1	n.a.	n.a.	n.a.
France	52	58.9	64.3	14.80	16.8	18.3	n.a.	7.9	8.0
Greece	16.05	16.1	16.1	5.49	5.5	5.5	n.a.	n.a.	n.a.
Israel	3.57	3.5	3.6	0.89	0.9	0.9	0.0	0.0	0.0
Italy	42.3	52.7	55.3	10.40	13.0	13.7	2.4	3.0	3.1
Jordan	26.74	26.7	26.7	7.49	7.5	7.5	n.a.	n.a.	n.a.
Lebanon	28.64	28.8	28.8	6.38	6.4	6.4	n.a.	n.a.	n.a.
Libya	23.18	23.2	23.2	4.7	4.7	4.7	4.0	4.0	4.0
Malta	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Monaco	n.a.	0.0	0.0	n.a.	0.0	0.0	n.a.	0.0	0.0
Montenegro	n.a.	48.4	48.4		8.0	8.0	n.a.	4.2	4.2
Morocco	16.76	19.6	20.0	5.02	6.0	6.1	0.1	0.1	0.1
North Macedonia	36.49	34.9	33.7	9.84	9.4	9.1	n.a.	n.a.	n.a.
Palestine	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Portugal	n.a.	20.5	20.5	n.a.	5.9	5.9	n.a.	0.5	0.5
San Marino	31.19	40.6	42.8	8.89	11.6	12.2	n.a.	n.a.	n.a.
Serbia	48.38	72.8	73.8	11.39	17.3	17.4	17.3	33.5	34.4
Slovenia	81.77	115.8	119.0	18.2	25.8	26.5	3.2	4.8	6.2
Spain	n.a.	26.2	27.3	n.a.	10.7	11.1	n.a.	n.a.	1.1
Syrian Arab Republic	23.49	23.5	23.5	7.06	7.1	7.1	n.a.	n.a.	n.a.
Tunisia	16.77	29.5	27.6	4.96	8.4	9.3	0.2	n.a.	n.a.
Türkiye	n.a.	22.2	25.7	n.a.	6.0	6.5	n.a.	0.2	0.2
All countries	**684.5**	**977.1**	**1 010.2**	**180.3**	**248.2**	**257.6**	**27.1**	**58.1**	**61.8**

Notes: Numbers in red are for 2015; n.a.: not available.

Preliminary estimates of the 2023 Mediterranean pilot study conducted as part of the Global Forest Resources Assessment Remote Sensing Survey

The Mediterranean region's diverse climate, rich biodiversity and long human history, which has heavily influenced the landscape, make it a critical area of study for forest area and forest area change. As pressures from socioeconomic development and climate change mount, the role of Mediterranean forests in providing sustainable land-use solutions becomes more crucial.

The following section presents preliminary findings from the pilot study for Mediterranean countries conducted as part of the new FRA 2025 RSS cycle. A capacity-building workshop was held in 2023 to train nationally nominated experts on interpreting the samples falling within their countries' borders.

Global Forest Resources Assessment Remote Sensing Survey: the Mediterranean pilot study

The results presented here describe the current state of Mediterranean forests and other main related land uses in 2023, based on the findings of the 2023 pilot study. The study tested the collection of certain additional land-use subclasses, including large-scale and small-scale grassland and cropland systems.

The pilot was carried out for 21 Mediterranean countries.[4] Within these countries, the study focused on three subzones that are part of the subtropical climate domain of the global ecological zones dataset: subtropical dry forest, subtropical steppe and subtropical mountain system (FAO and JRC, 2012). In this analysis, Mediterranean forest types, which are linked to the Mediterranean climate, are assumed to fall within these ecological subzones. Unlike the national-level data from the Global Forest Resources Assessment in the rest of Chapter 2, this pilot study applies a subregional approach based on FAO ecological zones.

The collection of data was based on the methodology of the FRA 2025 RSS, which uses a stratified random sampling design to derive robust estimates and reliable statistics, particularly for changes in forest area at the regional and global levels.

The samples were visually interpreted using freely available satellite imagery (Landsat and Sentinel-2) and the Open Foris cloud platform Collect Earth Online (CEO) (Saah *et al.*, 2019).

Mediterranean land-use areas in 2023

According to the RSS pilot study, forest area in the three subzones analyzed that are part of the subtropical climate domain in the Global Ecological Zones dataset (Subtropical Dry Forest, Subtropical Steppe, and Subtropical Mountain System) covered 46.9 million ha in 2023, with a 95 percent confidence interval of plus or minus 4 percent, which corresponds to 18 percent of the total Mediterranean land area (Figure 2.8, Table 2.5). Other wooded land in the Mediterranean pilot region covered an area of 24.6 million ha in 2023, that is, 10 percent of the total Mediterranean land area.

It is important to note that distinguishing between forest and other wooded land-use classes in the Mediterranean region is difficult, due to the complex Mediterranean scrub ecosystem. In these landscapes, the spatial resolution of the satellite imagery used for the RSS limits the interpreters' ability to distinguish between forest and other wooded land based on the 5 m tree height threshold.

Figure 2.8. Percent share of different land uses relative to total Mediterranean land area in the pilot region

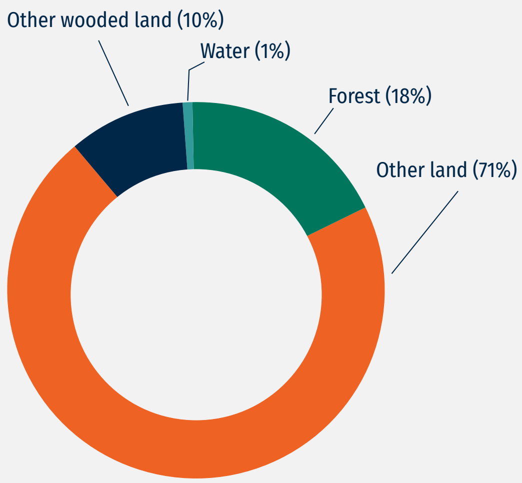


Table 2.5. Area of different land uses in the Mediterranean pilot region, 2023, and associated 95 percent confidence intervals

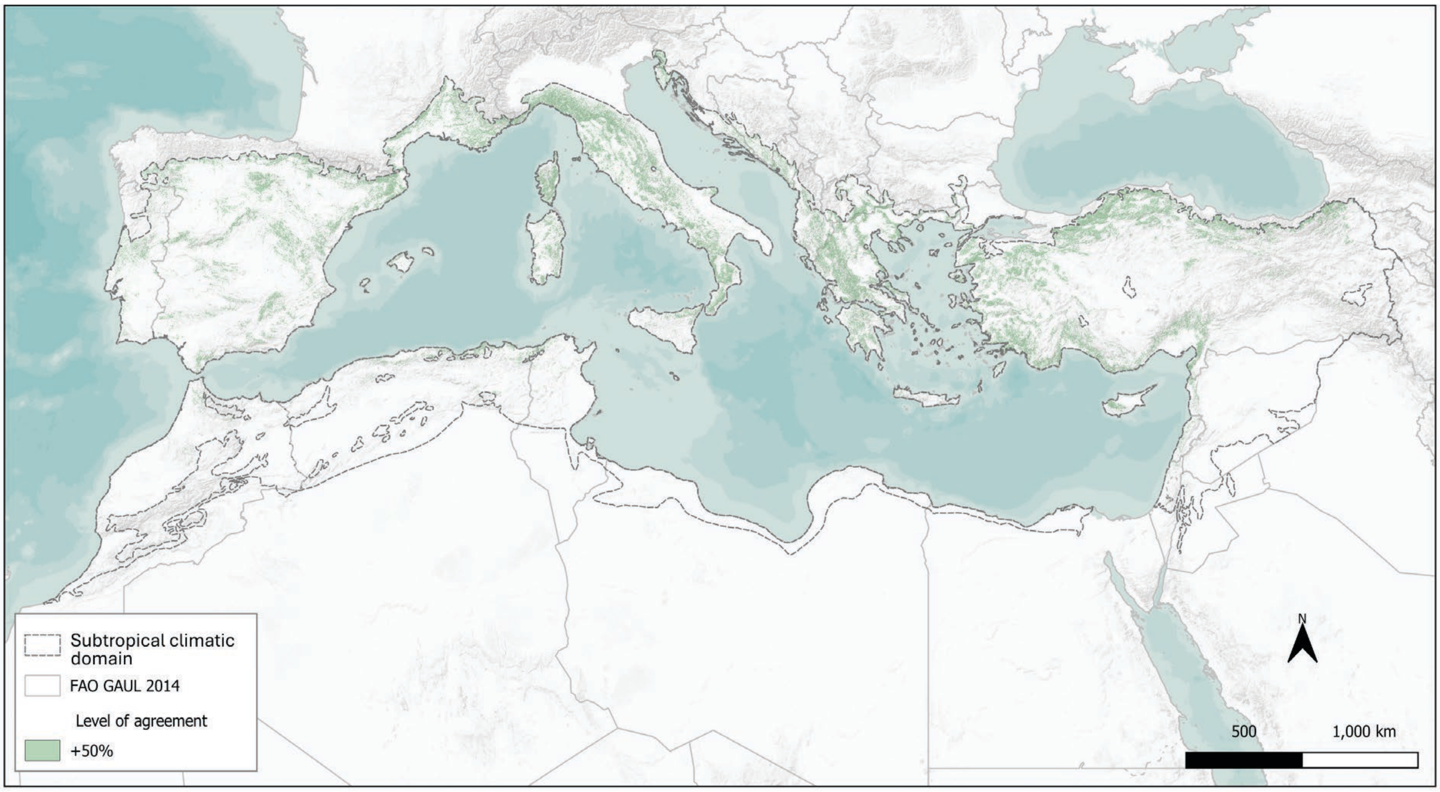
Forest (million ha)	±	Other land (million ha)	±
46.9	4%	183.3	2%
Other wooded land (million ha)	**±**	**Water (million ha)**	**±**
24.6	9%	3.4	25%

[4] The report covers the 21 signatory countries to the Barcelona Convention (Albania, Algeria, Bosnia and Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Libya, Malta, Monaco, Montenegro, Morocco, Slovenia, Spain, Syrian Arab Republic, Tunisia, Türkiye), but also the six following countries that are part of the Mediterranean bioclimatic basin: Bulgaria, Jordan, Palestine, Portugal, Serbia and North Macedonia (FAO and Plan Bleu, 2018).

Box 2.1.

Map of the spatial distribution of Mediterranean forest cover within the pilot region

To visualize the spatial distribution of Mediterranean forests, in the three ecological subzones analyzed (subtropical dry forest, subtropical steppe and subtropical mountain system), a comparative analysis of **eight** global geospatial maps[i] was conducted. An agreement level of 50 percent at pixel level among the different geospatial datasets was used. This means that if at least four out of the eight maps classified a pixel as forest, it was marked as forest in the final map.



Notes:

[i] Global Forest Change 2020 in Hansen et al. (2013); ESA's 2009 global land cover map; GlobeLand30 2020; Global PALSAR-2/PALSAR Forest/Non-Forest Map; Forest/Non-Forest (TanDEM-X) 2019; Copernicus Global Land Cover 2019; ESA WorldCover 10m 2020; and ESRI 2020 Land Cover.

This map of the Mediterranean forest cover was produced using a FRA geospatial module in the FRA reporting platform. It is a hybrid map produced from a comparison of the eight geospatial maps above. A level of agreement of 50 percent is used. This percentage reflects the probability of finding forest in the same pixel of half of the eight geospatial maps considered.

The Mediterranean forest area for this map is delimited by the three subzones that are part of the subtropical climate domain in the Global Ecological Zones dataset: Subtropical Dry Forest, Subtropical Steppe, and Subtropical Mountain System (FAO and JRC, 2012)

Refer to the disclaimer on page ii for the names and boundaries used in this map.

Sources:

Hansen, M.C., Potapov, P.V., Moore, R., Hancher, M., Turubanova, S.A., Tyukavina, A., Thau, D. *et al.* 2013. High-Resolution Global Maps of 21st-Century Forest Cover Change. *Science*, 342(6160): 850–853. https://doi.org/10.1126/science.1244693

FAO. 2014. United Nations Cartographic: The Global Administrative Layers Dataset. [Accessed on 26 May 2025].

United Nations Geospatial. 2020. Map geodata [shapefiles]. New York, USA, United Nations.

The estimates derived from the percentage of forest area within the subtropical climatic domain reported in FRA 2020, are well aligned with the RSS pilot results, which include three of the five subclimatic zones in that domain.

According to the RSS pilot study, cropland is the predominant land use, covering 34 percent of the total Mediterranean land area, followed by grassland at 27 percent, and bare soil and settlements at 5 percent each (Figure 2.9, Table 2.6). Altogether, these subclasses cover an area of 183.3 million ha, classified as other land.

The pilot study also collected data for "small-scale farming" and "large-scale farming" categories within the cropland and grassland subclasses. These were defined as follows by Branthomme *et al.* (2023):

- *Small-scale farming* consists of agricultural activities that apply non-industrial methods and low technology production processes, over limited areas, and for which the labour force is the main production investment.
- Large-scale farming consists of agricultural activities that apply industrial and medium-to-high technology production processes, extend over large areas, and are likely to involve significant capital investment on machinery or infrastructure.

Table 2.6. Land-use subclass areas and associated 95 percent confidence intervals in the Mediterranean region, 2023

Land-use subclasses, 2023	Million ha	±
Naturally regenerating forest	41.37	5%
Planted forest	5.50	17%
Cropland	87.11	5%
Grassland	70.18	7%
Settlements	12.74	15%
Water	3.43	24%
Other wooded land	24.64	11%
Bare soil	13.29	20%

The study also piloted the subdivision of cropland between temporary and perennial crops, defined as follows:

- *Temporary crops* are agricultural crops that are planted and harvested in a single growth cycle within a calendar year.
- *Perennial crops* are agricultural plantations that have a long useful life and produce crops for several consecutive years. These crops include fruit trees such as apple, orange and olive trees, as well as coffee and cocoa crops.

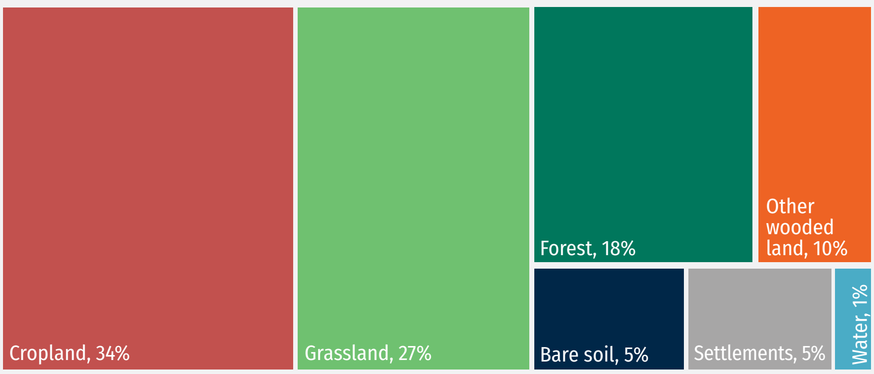
According to the pilot results, small-scale agriculture was the dominant cropland land-use type in the pilot region, with a share of 64 percent. The remaining 36 percent of cropland in the pilot region was managed through large-scale activities (Table 2.7).

Temporary crops accounted for 75 percent of cropland in the pilot region. Of these, 67 percent were managed for small-scale agriculture (Table 2.7).

Perennial crops represented 25 percent of cropland in the pilot region. Of these, 56 percent were managed for small-scale agriculture (Table 2.7).

Here, the "grassland" class includes all rangeland and pastureland. It also includes all natural grasslands, which are ecosystems naturally devoid of woody vegetation. In the Mediterranean pilot (Table 2.8), the grassland land use was subdivided

Figure 2.9. Distribution of the Mediterranean land area by FRA land-use classes, 2023, in the pilot region



into either "ranching" (if the main land use was raising livestock) or "non-managed grassland". The results show that around 70 percent of grassland in the Mediterranean was non-managed grassland. Of the grassland specifically used to raise livestock, 77 percent was small scale.

Mediterranean forest area change in 2000–2023

The results were analysed for trends in forest area losses and gains in the Mediterranean pilot region over the periods 2000–2010, 2010–2018 and 2018-2023.

The definitions used for this purpose are the following:

- Deforestation is defined as "the conversion of forest to another land use, independent of whether it is human-induced or not" (FAO, 2023).
- Forest area expansion is defined as "the expansion of forest on land that, until then, was under a different land use, involving a transformation of land use from non-forest to forest" (FAO, 2023). Forest area expansion can be natural or the result of afforestation.
- Forest area net change is the difference between forest area expansion and deforestation.

According to the pilot, between 2000 and 2023, 0.46 million ha of forest were lost in the Mediterranean pilot region due to deforestation, while 1.22 million ha of forest area were gained. The result was a forest area net expansion of 0.77 million ha over the whole period (Table 2.9).

The forest area annual net change decreased from 0.05 million ha/year in 2000–2010, to 0.04 million ha/year in 2010–2018 and to 0.01 million ha/year during the last period considered, 2018–2023 (Table 2.9).

Table 2.8. Grassland area in the Mediterranean pilot region by management type, and associated 95 percent confidence intervals, 2023

Grassland management type	Area (million ha)	±
Non-managed grassland	48.94	9%
Large-scale ranching	4.83	28%
Small-scale ranching	16.40	16%
Total	**70.18**	**8%**

Table 2.9. Annual deforestation, annual forest area expansion and forest area annual net change in the Mediterranean pilot region, and associated 95 percent confidence intervals, 2000–2010, 2010–2018 and 2018–2023

	2000–2010	2010–2018	2018–2023
Annual deforestation (million ha/year)	0.020	0.027	0.009
±	40%	71%	50%
Annual forest expansion (million ha/year)	0.065	0.062	0.014
±	39%	54%	54%
Annual forest area net change (million ha/year)	0.05	0.04	0.01
±	58%	107%	155%

Table 2.10. Total land-use change area in the Mediterranean region and associated 95 percent confidence intervals, 2000–2023

Deforestation (million ha)	±	Forest expansion (million ha)	±
0.46	38%	1.22	30%

In conclusion, the analysis shows that forest areas in the Mediterranean region have remained largely stable over the past two decades. Land-use changes, including deforestation and forest expansion, have been minimal and are showing a declining trend. However, the limited number of land-use change samples identified during the pilot study results in large confidence intervals, which lowers the statistical reliability of these results. While the overall patterns suggest a consistent forest landscape, further monitoring and data collection are needed to confirm these trends more reliably.

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FAO & JRC (European Commission Joint Research Centre). 2012. Global forest land-use change 1990–2005, by E.J. Lindquist, R. D'Annunzio, A. Gerrand, K. MacDicken, F. Achard, R. Beuchle, A. Brink, H.D. Eva, P. Mayaux, J. San-Miguel-Ayanz & H-J. Stibig. FAO Forestry Paper No.169. Rome, FAO and JRC.

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Saah, D., Johnson, G., Ashmall, B., Tondapu, G., Tenneson, K., Patterson, M., Poortinga, A. *et al.* 2019. Collect Earth: An online tool for systematic reference data collection in land cover and use applications. Environmental Modelling & Software, 118: 166–171. https://doi.org/10.1016/j.envsoft.2019.05.004

Further reading

FRA 2020 national reports reviewed to compile the status of Mediterranean forests 2025, https://www.fao.org/forest-resources-assessment/fra-2020/country-reports/en/:

Global Forest Resource Assessment 2020 Desk Study Albania

Évaluation des ressources forestières mondiales 2020 Rapport Algérie

Global Forest Resource Assessment 2020 Desk Study Bosnia and Herzegovina

FAO 2020 Global Forest Resource Assessment 2020 Report Bulgaria

FAO 2020 Global Forest Resource Assessment 2020 Report Croatia

FAO 2020 Global Forest Resource Assessment 2020 Report Cyprus

FAO 2020 Global Forest Resource Assessment 2020 Report Egypt

Évaluation des ressources forestières mondiales 2020 Rapport France

FAO 2020 Global Forest Resource Assessment 2020 Report Greece

FAO 2020 Global Forest Resource Assessment 2020 Report Israel

FAO 2020 Global Forest Resource Assessment 2020 Report Italy

FAO 2020 Global Forest Resource Assessment 2020 Report Jordan

Évaluation des ressources forestières mondiales 2020 Rapport Liban

Global Forest Resource Assessment 2020 Desk Study Libya

FAO 2020 Global Forest Resource Assessment 2020 Report Malta

Évaluation des ressources forestières mondiales 2020 Étude de bureau Monaco

FAO 2020 Global Forest Resource Assessment 2020 Report Montenegro

Évaluation des ressources forestieèes mondiales 2020 Rapport Maroc

Global Forest Resource Assessment 2020 Desk Study North Macedonia

Global Forest Resource Assessment 2020 Desk Study Palestine

FAO 2020 Global Forest Resource Assessment 2020 Report Portugal

Global Forest Resource Assessment 2020 Desk Study San Marino

FAO 2020 Global Forest Resource Assessment 2020 Report Serbia

FAO 2020 Global Forest Resource Assessment 2020 Report Slovenia

Evaluación de los Recursos Forestales Mundiales 2020 Informe España

FAO 2020 Global Forest Resource Assessment 2020 Report Syrian Arab Republic

Évaluation des ressources forestières mondiales 2020 Rapport Tunisie

FAO 2020 Global Forest Resource Assessment 2020 Report Türkiye

Chapter 3
Drivers of degradation in Mediterranean forest ecosystems

Maria Mercedes Caron
European Forest Institute (EFI), Barcelona, Spain
Magda Bou Dagher Kharrat
European Forest Institute (EFI), Barcelona, Spain
Eduard Mauri
European Forest Institute (EFI), Barcelona, Spain
Pio Federico Roversi,
CREA Research Centre for Plant Protection and Certification, Florence, Italy
Shiroma Sathyapala,
Food and Agriculture Organization of the United Nations, Rome, Italy
Dimitrios N. Avtzis,
Forest Research Institute, Hellenic Agricultural Organization Demeter, Athens, Greece
Andrea Battisti
University of Padua, Italy
Manuela Branco,
Forest Research Centre, School of Agriculture, University of Lisbon, Portugal
Thomas Boivin,
Ecology of Mediterranean Forests, National Research Institute for Agriculture, Food and Environment (INRAE) Avignon, France
Mustapha Gachi,
National Institute of Forestry Research, Cheraga, Algeria
Pilar Fernandez-Conradi,
Ecology of Mediterranean Forests, National Research Institute for Agriculture, Food and Environment (INRAE) Avignon, France
Maria J. Lombardero,
Unit of Sustainable Environmental and Forest Management, University of Santiago de Compostela, Spain
Zvi Mendel,
Plant Protection Division, Agricultural Research Organisation (ARO), Bet Dagan, Israel
Pedro Naves,
National Institute for Agricultural and Veterinary Research (INAV), Oeiras, Portugal
Nabil Nemer,
Holy Spirit University of Kaslik, Lebanon
Giuseppino Sabbatini-Peverieri1
CREA Research Centre for Plant Protection and Certification, Florence, Italy

Introduction

Mediterranean ecosystems are under threat from accelerated climate change, including warming, changes in precipitation and increases in extreme weather events, and from rises in sea level, increased salinity and acidification, the arrival and expansion of non-indigenous species, and pest outbreaks. These drivers of degradation are damaging both natural ecosystems and human livelihoods (Gauquelin *et al.*, 2018) and are projected to intensify in the coming decades, further exacerbating their impacts and jeopardizing essential ecosystem services. Additionally, multiple drivers of degradation are anticipated to have synergistic effects on ecosystems, with projections suggesting these effects will be particularly pronounced if global mean temperatures surpass 1.5 °C to 2° C above pre-industrial levels (MedECC, 2020; Morán-Ordóñez *et al.*, 2021). Mitigating the isolated and joint effects of such drivers on Mediterranean ecosystems first requires that we understand them better (MedECC, 2020).

Climate and land-use change, wildfires, the arrival and expansion of alien species, pest and disease outbreaks, and cattle grazing and browsing are among the most significant drivers of degradation in Mediterranean forests (Underwood *et al.*, 2009). Climate change, including climate warming, increased aridity, and more frequent and prolonged droughts, is strongly affecting the performance of forest species. It can also lead to changes in forest species physiology and phenology, alter forest composition and contribute to forest dieback (Bellard *et al.*, 2012; Carnicer *et al.*, 2011; Gentilesca *et al.*, 2017; Ogaya and Peñuelas, 2021). Land-use change can result in a variety of both positive and negative, and direct and indirect impacts, depending on the characteristics of the specific area considered. It can lead to an increase in soil erosion and a decrease or increase in biodiversity, and can contribute to landscape homogenization and heighten the likelihood of wildfires (García-Ruiz *et al.*, 2020; Karamesouti *et al.*, 2015; Queiroz *et al.*, 2014; Stoate *et al.*, 2009). Between 2011 and 2023, wildfires burned on average approximately 600 000 hectares (ha) of land annually, posing an extremely severe threat to Mediterranean forests and the ecosystem services they provide (Baudena *et al.*, 2023). The expansion of invasive alien species can significantly worsen the phytosanitary condition of Mediterranean forests. Alongside native pests and diseases, such species can trigger severe outbreaks in newly invaded territories, causing devastating impacts. Cattle browsing and grazing, along with other human activities, contribute to environmental decline, and soil erosion and degradation in Mediterranean forests. However, they can also reduce fire risks if carried out in a controlled, planned and sustainable way (Schoenbaum *et al.*, 2018; Teruel-Coll *et al.*, 2019).

In light of the numerous pressures faced by Mediterranean forest ecosystems, urgent action is required to mitigate forest degradation and secure the continuous provision of ecosystem services (Nocentini, Travaglini and Muys, 2022). Increased efforts are needed to understand the isolated and combined effects of degradation drivers, implement measures to mitigate these effects, and enhance the adaptive capacity and resilience of forests.

Climate change

Climate change poses serious challenges to Mediterranean forests. Rising temperatures, changes in precipitation patterns and more frequent extreme weather events, such as warm spells and droughts, threaten the stability and resilience of forest ecosystems. Climate change can affect forests when, for example, the physiological tolerance of species is exceeded, inducing phenological mismatches, increasing the risk of wildfires, and decreasing the organic matter content and nutrient availability of the soil (Carnicer *et al.*, 2011; Gentilesca *et al.*, 2017; Maaroufi and De Long, 2020; Newbold *et al.*, 2020; Ogaya and Peñuelas, 2021; Trumbore, 1997). Moreover, climate change intensifies existing pressures on Mediterranean forests, such as population growth, leading to an increased demand for natural resources, urban expansion, deforestation and land degradation. These combined factors contribute to habitat degradation and loss (Gauquelin *et al.*, 2018; Zdruli, 2014).

The negative impacts of climate change on Mediterranean forests are expected to increase, affecting the provision of ecosystem services (Balzan, Sadula and Scalvenzi, 2020; IPBES, 2019; MedECC, 2020; Morán-Ordóñez *et al.*, 2021; Nocentini, Travaglini and Muys, 2022). Proper consideration of these impacts is necessary to develop an effective forest management strategy for strengthening the adaptation and resilience of forests to the challenges of a changing world (Nocentini, Travaglini and Muys, 2022). Moreover, considering that climate change is expected to be especially severe in the Mediterranean, developing cross-border adaptation and mitigation strategies is crucial, along with international cooperation and conservation efforts, for ensuring the preservation of Mediterranean forests in the face of climate change.

Climate warming

The Mediterranean region is experiencing climate warming at an accelerated rate, with the Mediterranean Sea warming three times faster than the oceans (MedECC, 2020). Warming in the region is leading to rises in sea level, higher rates of coastal erosion, and an increase in the frequency and intensity of extreme weather events, including heat waves, droughts and floods (IPCC, 2019; MedECC, 2020). Moreover, climate change is worsening desertification and drought stresses, undermining the adaptation and mitigation capacities of local ecosystems (IPCC, 2019), which is affecting economic activities and human health (Patz *et al.*, 2005). These impacts are expected to persist, as the region is predicted to remain among the most affected in the world, particularly in terms of changes to the hydrological cycle (IPCC, 2019; MedECC, 2020), and especially if global warming reaches or exceeds the threshold of 1.5 °C to 2 °C above pre-industrial levels (IPCC, 2019; MedECC, 2020).

Robust evidence shows that temperatures in the Mediterranean have been increasing significantly and continuously (IPCC, 2019; MedECC, 2020). Warming in the order of 0.1-0.5 °C per decade has been recorded since the 1980s (Lange, 2020; Lelieveld *et al.*, 2012; Lionello and Scarascia, 2018; Mariotti *et al.*, 2015). Moreover, the combined analysis of land and sea areas shows that the mean annual temperature is currently 1.54 °C warmer than during 1860–1890, which represents warming 0.4 °C higher than the global average (MedECC, 2020). In addition, warming recorded in the last two decades (2000–2019) was 0.8 °C on average, with 1 °C more in summer and 0.41 °C more in winter (MedECC, 2020).

Future projections indicate that the Mediterranean basin is among the regions that will experience elevated warming, making it one of the most prominent climate change hot spots in the world (Diffenbaugh and Giorgi, 2012; Giorgi, 2006; Giorgi and Lionello, 2008). An estimation based on state-of-the-art regional simulations (EURO-CORDEX regional model simulations) indicates that over land, warming in the order of 0.9–5.6 °C with respect to the reference period 1980–1999 is expected between 2020 and 2100, but the degree of warming projected will vary depending on the season, emission concentration scenarios and the area of the Mediterranean considered.

The average annual warming over land across the region is expected to be between 1.1 °C and 5.3 °C, with maximum increases during summer (5.3 °C) and less warming during winter (1.1 °C) (MedECC, 2020). Under a low Representative Concentration Pathway (RCP2.6), expected warming will likely be between 1.1 °C and 1.5 °C, while under a high Representative Concentration Pathway (RCP8.5), expected warming may be between 1.3 °C and 5.3 °C (IPCC, 2019; MedECC, 2020). Moreover, it is expected that regional average warming will exceed the global mean by 20 percent when considering annual values and by 50 percent when considering summer values (MedECC, 2020).

Precipitation change

As a consequence of climate warming, the water cycle has also changed, and most models predict that these changes will intensify and that the climatic conditions will become drier throughout the Mediterranean region (Giorgi and Lionello, 2008; Kyselý *et al.*, 2012; Tramblay and Somot, 2018). Observed changes in precipitation show significant spatial variability and are influenced by the time frame and season under consideration. For instance, across much of the Mediterranean region, a predominantly decreasing trend in annual and winter precipitation was observed between 1950 and 2018. However, this pattern is reversed when focusing solely on the period from 1980 to 2018 (MedECC, 2020). These contradictory trends are due to the strong and marked multidecadal variability of precipitation in the Mediterranean, which may mask the trends resulting from greenhouse gas emissions-induced climate change. Thus, the confidence in the detection of human-induced changes in precipitation in the historical past is low (Lelieveld *et al.*, 2012; Peña-Angulo *et al.*, 2020). However, there has been a relatively marked decreasing trend in winter precipitation over the central and southern portions of the basin since the second half of the twentieth century (MedECC, 2020).

The projections, produced based on general circulation-model (GCM) and regional climate-model (RCM) ensembles, predict predominantly drier conditions in the twenty-first century throughout the region in summer and spring, and in most of the Mediterranean in winter (MedECC, 2020). Nevertheless, the magnitude and exact pattern of precipitation decrease vary widely across models and as a function of the scenarios considered. Under high greenhouse gas concentration scenarios, the different models predict a precipitation decrease of between 10 percent and 40 percent (Giorgi and Lionello, 2008; IPCC, 2007). Moreover, not only is the precipitation amount expected to change, climate projections also predict an increase in interannual precipitation variability, higher precipitation intensity and greater precipitation extremes, as well as decreased precipitation frequency and longer dry spells, especially in summer and in Southern Mediterranean countries (MedECC, 2020).

Extreme weather events

Trends in the Mediterranean show an increase in the frequency and duration of extreme heat events over the past few decades (Zittis *et al.*, 2022). At the global level, 2023 was the warmest year on record, with a global average (near-surface temperature) of 1.45 °C above the pre-industrial baseline (WMO, 2023). In many parts of the Mediterranean, severe record-breaking summer-heat extremes have been recorded in recent decades (Coumou and Rahmstorf, 2012), while the number of tropical nights (nights with a minimum temperature above 20 °C) has increased over most of the Mediterranean, including in North Africa and the Near East and in the southern parts of Europe (Ceccherini *et al.*, 2017; Kostopoulou and Jones, 2008; Lelieveld *et al.*, 2016; Nashwan, Shahid and Abd Rahim, 2019; Tolika, 2019).

Models predict an increase in the frequency and severity of heat waves in the near and far future (Diffenbaugh and Giorgi, 2012; Giorgi and Lionello, 2008; Lelieveld *et al.*, 2016; Russo *et al.*, 2014). With a global warming of 2 °C above pre-industrial levels, maximum daytime temperatures in the Mediterranean will likely increase by 3.3 °C. Moreover, under a high Representative Concentration Pathway scenario (RCP8.5), the

Box 3.1.

Drought in the Mediterranean region – January 2024

In early 2024, the European Commission Joint Research Centre released the report *Drought in the Mediterranean Region – January 2024*, highlighting the concerning persistence of droughts and their impact in the region. According to the report, most of the Mediterranean region experienced above-average temperatures throughout 2023, with consecutive acute warm spells occurring between September and December, making 2023 the hottest year on record according to the Copernicus Climate Change Service. Furthermore, from 1 January to 20 January 2024, severe drought conditions gripped the Mediterranean, affecting water resources and resulting in water-use restrictions in Morocco, Portugal and Spain. In Morocco, which experienced six consecutive years of drought, water reservoir levels were critically low, with dams filled on average around 23 percent, and severely reduced irrigation capacity. Similarly, in Catalonia, Spain, drought emergency was declared on 1 February 2024, when the water reserves fell below 16 percent, leading to water-use restrictions.

The report indicated that the severe drought, coupled with prolonged periods of above-average temperatures and warm spells, drastically impacted soil moisture and vegetation growth, particularly in northern Africa, the coastal areas of Spain and most of the Mediterranean islands. Moreover, elevated fire risk was reported for northern Africa and in southeastern Spain by the European Forest Fire Information System (EFFIS) of the Copernicus Emergency Management Service, due to high temperatures, extensive drought and the high availability of flammable material.

Source: Toreti, A., Bavera, D., Acosta Navarro, J., Arias Muñoz, C., Barbosa, P., Jager, A. de, Ferraris, L. et al. 2024. *Drought in the Mediterranean region: January 2024: GDO analytical report*. Luxembourg, Publications Office of the European Union. https://data.europa.eu/doi/10.2760/384093 maximum daytime temperature is expected to be up to 7 °C warmer than in the recent past by the end of the twenty-first century (Lelieveld *et al.*, 2016; Sillmann *et al.*, 2013). An increase of up to 60 percent in the number of tropical nights is also expected in some parts of the Mediterranean (Dosio and Fischer, 2018). In summer, the increase in temperature extremes will be dramatic, particularly if the global temperature increases by 4 °C. Under such a scenario, almost all nights will be tropical, and there will be no cold days (days where the maximum temperature, or nights where the minimum temperature, fall below the tenth percentile) (Dosio and Fischer, 2018; Sillmann *et al.*, 2013).

Moreover, in the Mediterranean, the generalized warming and increase in extreme temperatures are expected to be combined with increasing precipitation intensity, lower precipitation frequency and longer dry spells (especially in summer) (Sillmann *et al.*, 2013; Zittis *et al.*, 2022). This will have significant impacts on water resources and soil moisture, which in turn will affect vegetation growth and performance, as well as the availability of resources for human use (García-Ruiz *et al.*, 2011).

Land-use change

Land-use change is a primary anthropogenic driver of the degradation and alteration of the Earth's surface biophysical properties and a major contributor to climate change (Newbold *et al.*, 2015; Searchinger *et al.*, 2018). The interaction between climate and land-use change is particularly significant in the Mediterranean basin due to the region's vulnerability to regional and global climate change, its high population density and its history as the cradle of ancient civilizations (Holmgren *et al.*, 2016).

Land-use change in the Mediterranean basin has a history spanning several thousand years (Holmgren *et al.*, 2016), but it intensified in the Late Holocene (Pilotto, Rojas and Buckland, 2022). This long history of land use has led to the development of valuable cultural landscapes over the centuries (Blondel *et al.*, 2010; Tieskens *et al.*, 2017). The Mediterranean basin, with its unique blend of rich cultural influences, high biodiversity, diverse environmental features, and extensive history of land use, hosts a variety of land systems that create a mosaic intricately linking human activities and natural environmental conditions (Malek *et al.*, 2018).

In recent years, land use in the region has intensified due to the rising demand for goods and services, increased industrialization, which has decoupled consumption from production, and shifts in the global diet (Lambin and Meyfroidt, 2011). Increasing pressure from land-use change is threatening natural and semi-natural habitats, leading to the degradation of soil and water resources (García-Ruiz *et al.*, 2011; Karamesouti *et al.*, 2015). In this context, sustainable land-use practices and ongoing assessment of temporal and spatial changes in land use and land cover are essential for effectively addressing current land use-related challenges (Fragou *et al.*, 2020).

In the Mediterranean, the conditions of land-use change differ across the region. For many years, the eastern and southern parts of the region have been strongly affected by increasing demographic pressure and a growing reliance on food imports (Wright and Cafiero, 2011). In 2021, 431 690 square kilometres (km^2) of land were croplands (FAO, 2025) with relatively low yields, meaning that there is a need to intensify production and expand the area of cropland to satisfy the demand for food (Mueller *et al.*, 2012). However, these changes may exacerbate soil degradation and increase the demand for water, and appropriate land management practices are necessary to mitigate these effects (García-Orenes *et al.*, 2012; García-Ruiz *et al.*, 2011). The northern part of the Mediterranean region generally hosts intensive agricultural systems (Malek *et al.*, 2018). However, in this portion of the Mediterranean, the abandonment of traditional livestock grazing systems due to low economic competitiveness and reduced livestock productivity is a severe problem, which leads to land abandonment (Bernués *et al.*, 2011; Malek *et al.*, 2018).

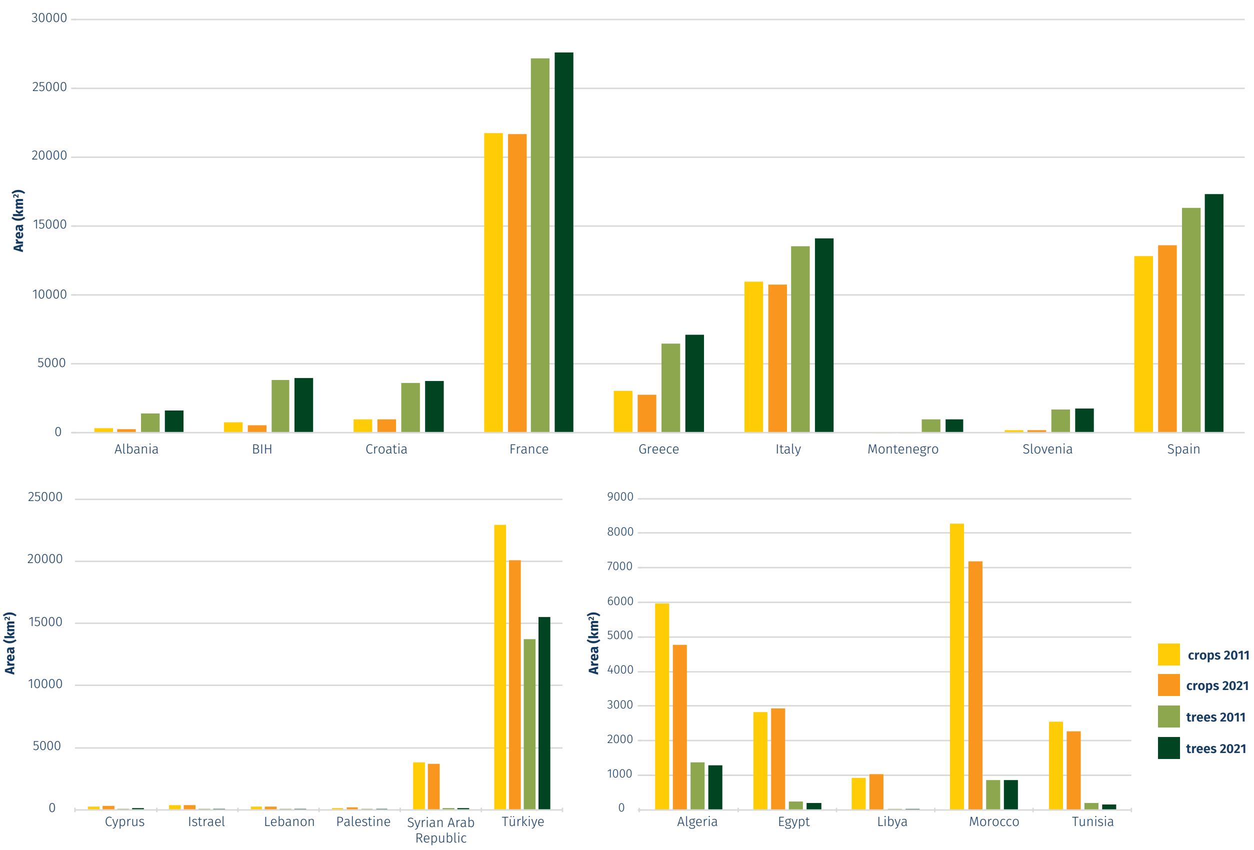
Changes in land use have resulted in variations in the proportion of Mediterranean land allocated to forests and crops. Recent data indicate that from 2011 to 2021, tree-covered areas[5] increased by 4.8 percent (approximately 46 808 km^2), while herbaceous croplands[6] decreased by 5.6 percent (approximately 53 038 km^2) (FAO, 2025). In Northern Mediterranean countries, forest cover increased by 4.0 percent, while croplands decreased by 0.35 percent between 2011 and 2021. Changes in the same direction but with greater intensity were observed in Eastern Mediterranean countries, where forest cover increased by 13.2 percent, while crop cover decreased by 10.1 percent during the same period. In contrast, between 2011 and 2021, the surface cover of forests and cropland in Southern Mediterranean countries decreased by 6.7 percent and 11.4 percent, respectively. However, there were marked differences between countries throughout the Mediterranean (Figure 3.1).

The changes observed indicate that the situation varies across the region. In Northern and Eastern Mediterranean countries, there was an increase in forest cover and a decrease in land dedicated to crops. The change was much more pronounced in the Eastern Mediterranean countries compared to the Northern Mediterranean countries. The observed increase in forest cover is likely due, at least in part, to forests colonizing abandoned settlements, croplands and grasslands in mountainous and rural areas. In both regions, a

5 Any geographical area dominated by natural tree plants with a cover of 10 percent or more. Other types of plants (shrubs and herbs) can be present, even with a density higher than that of the trees. Areas planted with trees for afforestation purposes and forest plantations are included in this class (FAO, 2025).

6 Geographical area with a main layer of cultivated herbaceous plants (graminoids or forbs). These can include herbaceous crops used for hay. All the non-perennial crops that do not last for more than two growing seasons and crops like sugar cane, where the upper part of the plant is regularly harvested while the root system can remain for more than 1 year in the ground, are included in this class (FAO, 2025).

Figure 3.1. Area covered by crops and forests in Mediterranean countries, 2021



Source: FAO. 2024. FAOSTAT: Land Cover. [Accessed on 25 April 2025]. https://www.fao.org/faostat/en/#data/LC. Licence: CC-BY-4.0.

Note: Malta and Monaco have not been plotted due to the low area reported.

thorough evaluation of the forest characteristics is necessary to gain a better understanding of forest quality and design and to implement the most suitable forest management approaches. In the Southern Mediterranean countries, the forest cover declined during the period in question as other land uses became more prevalent. This trend can have important consequences as it can jeopardize the continuous provision of ecosystem services, especially in the context of climate change.

The cropland area in the Northern, Eastern and Southern Mediterranean countries declined from 2011 to 2021. The reasons for this observed trend are manifold, including increased land degradation and abandonment, which have led to the conversion of croplands to other land uses such as natural forests and scrubland (Zdruli, 2014). In some areas, the increased specialization of agricultural systems may have resulted in a decrease in cropland areas.

In this context of change, it is crucial to monitor land use and land-use change using land monitoring and surveying tools. This will improve our understanding of the extent of this change, the driving forces behind it, and its consequences for ecological processes and agroecosystems (Balzan, Sadula and Scalvenzi, 2020; Hasan *et al.*, 2020; Nieto-Romero *et al.*, 2014). Continuous monitoring is particularly important in the Mediterranean as land-use change scenarios suggest that crop production and grazing will intensify, while urbanization will increase (van Asselen and Verburg, 2012; Souty *et al.*, 2012). However, these predictions fail to account for local distinct features and threats that can alter these processes, such as traditional mosaic systems and landscapes (Malek *et al.*, 2018) and the reduced water availability affecting the region.

Land abandonment

Changes in socioeconomic conditions have led to land abandonment in many regions of the world. This process has involved a shift towards less intensive land use, including completely ceasing the use and management of the soil, Palestine when it shows no signs of management for at least 4 years (Baudry, 1991; Prishchepov, Schierhorn and Löw, 2021). Land abandonment has been reported in various regions worldwide (Quintas-Soriano, Buerkert and Plieninger, 2022). Land abandonment is particularly pronounced in the Mediterranean where landscapes experience two contrasting yet interrelated processes: abandonment of rural, less economically developed areas coexisting with agricultural intensification in others (García-Ruiz *et al.*, 2020). These processes are closely intertwined, making agricultural intensification one of the main drivers of rural abandonment (Filho *et al.*, 2017).

Land abandonment can result in a variety of outcomes that can promote or undermine the provision of ecosystem services and quality of life depending on the location, area, and social and ecological context (Ustaoglu and Collier, 2018; van der Zanden *et al.*, 2017). Land abandonment can support ecological restoration and the recovery of natural vegetation. In some cases, it can enhance carbon storage, wood provision and nutrient availability while also improving local water quality by regulating the hydrological cycle, and improving overall habitat quality and biodiversity conservation (Cramer, Hobbs and Standish, 2008; Queiroz *et al.*, 2014; Stoate *et al.*, 2009; Ustaoglu and Collier, 2018). However, in other cases, land abandonment can have negative effects on biodiversity conservation and other ecosystem services derived from traditional agricultural landscapes. In such instances, land abandonment can lead to increased soil erosion, reduced water availability and heightened wildfire risk due to landscape homogenization combined with the accumulation of inflammable biomass (Bentley and Coomes, 2020; Ruiz-Flaño, García-Ruiz and Ortigosa, 1992; Sluiter and De Jong, 2007; Stoate *et al.*, 2009). This landscape homogenization significantly impacts biodiversity as well as local identity and cultural heritage (Quintas-Soriano, Buerkert and Plieninger, 2022).

In the future, the drivers of land abandonment are expected to intensify. For example, in the European Union, around 30 percent (approximately 56 million ha) of agricultural areas are at moderate or high risk of land abandonment (Schuh *et al.*, 2020), with remote areas, mountains, islands, and coastal and sparsely populated areas particularly at risk (Salis *et al.*, 2022). Unfortunately, less information is available for other regions like the Eastern and Southern Mediterranean. Continuous monitoring is essential to better understand the driving forces behind this process and its effects on various ecosystem services.

Soil degradation and desertification

Land and soil degradation has been a persistent issue in the Mediterranean since ancient times, but it is currently being worsened by climate change and land-use intensification. Soil degradation is typically defined as a decline in soil health, which refers to the ability of soil to continuously function as a vital living ecosystem that sustains plants, animals and humans (Lehmann *et al.*, 2020). This degradation can result in reduced productivity and may even lead to a complete loss of the soil's ability to provide essential ecosystem services (Abbott and Manning, 2015; Pereira *et al.*, 2018). Soil degradation can be classified as physical degradation, which includes soil sealing, compaction and erosion; chemical degradation, which encompasses organic matter mineralization, soil contamination, salinization and sodification; and biological degradation, characterized by a decrease in the soil's pool of organisms, ranging from microbes (bacteria and fungi) to macrofauna (e.g. collembola and nematodes) (Ferreira *et al.*, 2022). The key factors of soil degradation in the region are (i) soil erosion caused by rainfall and other climatic agents; (ii) loss of soil organic matter in areas already characterized by low or very low soil organic matter; and (iii) soil and water salinization (Álvaro-Fuentes *et al.*, 2009; Diodato *et al.*, 2022; Herrero and Pérez-Coveta, 2005). Its primary drivers are population growth and the intensification of socioeconomic activities, which lead to land-use change (Ferreira *et al.*, 2022).

The Mediterranean region is one of the areas most vulnerable to soil degradation. Approximately 30 percent of its land area is considered to have "very high sensitivity" or "high sensitivity" to desertification (IPCC, 2019). Given the intrinsic characteristics of the region's soils and the significant challenges posed by soil degradation, implementing sustainable soil management practices is essential. These practices are crucial for mitigating the adverse effects of degradation, ensuring the long-term health and productivity of soils, and helping reduce land-use change while preserving existing forest cover. Sustainable soil management practices can contribute to mitigating the impacts of climate change by promoting carbon sequestration in soils and improving their ability to withstand extreme weather events, such as droughts and floods.

Wildfires

Interannual rainfall variability (Deitch, Sapundjieff and Feirer, 2017) has a strong impact on the occurrence of forest fires. According to the EFFIS European Fire Database, which registers and maps fires of 30 ha or larger (JRC, 2024), the area burnt each year is highly variable. Between 2011 and 2023, the average total annual area burnt in Mediterranean countries[7] was 616 486 ha. However, in 2017, the burnt area soared to 1 324 227 ha, which was nine times greater than the following year, when only 146 334 ha were burnt.

Considering the proportion of burnt area in relation to the total country area, the worse years were 2012, 2017 and 2020 to 2022. Between 2011 and 2023, the countries most affected were Montenegro, with 18.7 percent of its territory burnt, followed by Portugal with 15.3 percent, and Bosnia and Herzegovina with 10.2 percent. In comparison, Greece and Spain, which often experience and report catastrophic wildfires, had 4.2 percent and 2.3 percent of their territory burnt over this 13-year period.

In 2017, Montenegro reported its worst fire season in a decade. A total of 51 661 ha were affected, representing 3.86 percent of its territory and six times the area burnt during the previous year. The fire events were extraordinarily extensive, with one single event affecting 11 percent of that total burnt area (5 687 ha) (San-Miguel-Ayanz *et al.*, 2019). In this context, hundreds of tourists and residents had to be evacuated from the Luštica peninsula, and the Montenegrin Government required international aid to fight the fires. The

[7] Albania, Algeria, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Libya, Montenegro, Morocco, North Macedonia, Palestine, Portugal, Serbia, Slovenia, Spain, Syrian Arab Republic, Tunisia and Türkiye.

years 2020 and 2021 were also critical for the country. A devastating fire occurred between 8 and 24 August 2021, affecting 15 516 ha and accounting for 35.7 percent of the total area burnt that year. Fortunately, the direct human impact of this fire was minimal as it occurred in a largely unpopulated mountainous forest area.

Although most wildfires in the Mediterranean basin occur in July and August, exceptional weather conditions may trigger devastating fires in other months when fires are less common. In October 2017, Portugal experienced a fire that decimated 289 124 ha (53.5 percent of the total area burnt that year, accounting for 6.1 percent of the Portuguese territory), with 3 234 ignitions (JRC, 2024). These fires were caused by the combination of weather conditions including dry winds – causing the foci to spread across northern Portugal – and the traditional practice of farmers burning woody agricultural residues at the end of the growing season.

European Mediterranean countries, which have a larger forest cover compared to Southern and Eastern Mediterranean countries, account on average for 79 percent of the annual area burnt in the region. In exceptional years, this percentage can be higher, as reported in 2018, when 96 percent of the forest area burnt in the Mediterranean was in Europe.

The number of fires and the area burnt are correlated, and the average fire size tends to be relatively constant each year, except during years when catastrophic fires occur. For example, in Greece, the average size of wildfires usually ranges from 170 ha to 630 ha. However, in 2021, the average fire size was 1 538 ha, and in 2023, it increased to 3 120 ha. Similarly, in Portugal, the average fire size is typically between 140 ha and 530 ha, but in 2017, it rose to 1 381 ha. Portugal, Greece, Croatia, Türkiye, Morocco, Algeria, Libya, the Syrian Arab Republic and Palestine show grater variability in average fire size.

In Mediterranean countries, natural ignitions accounted for only a very small share of the fire causes reported in 2019. In most countries, fewer than 10 percent of ignitions were from natural causes, with the highest figures being reported by Türkiye (11 percent) and Lebanon (9 percent). However, the capacity of various agencies to determine the causes of fires varies greatly. In 2019, Bulgaria, Portugal and Lebanon reported that fewer than 20 percent of the fires were of unknown origin, indicating that more than 70 percent of them were attributable to human causes. On the other hand, Croatia, France and Türkiye reported that the causes of fires were unknown in more than half of the events, and that fewer than 41 percent of the fires could be attributed to human causes (San-Miguel-Ayanz *et al.*, 2021).

Grazing and browsing

Livestock grazing is an important socioeconomic activity in the Mediterranean region, and Mediterranean, woodlands are traditional agrosilvopastoral systems that have been shown to provide nutritional supplements for cattle (Bugalho *et al.*, 2011; Casasús *et al.*, 2007). The role of woody species in mixed feeding is key in the Mediterranean as ungulates normally graze on grass in spring and browse on woody plants during the dry summers and cold winters (Rogosic *et al.*, 2006; Velamazán, Perea and Bugalho, 2020). Over the past few years, grazing regimes have changed in many areas, shifting from livestock grazing, mainly from goats (Papanastasis *et al.*, 2008), to both domestic and wild ungulate grazing (San Miguel, Perea and Fernández-Olalla, 2010).

In recent decades, significant changes in economic activities have led to shifts in land-use patterns and alterations in the structure and composition of vegetation (López-Sánchez *et al.*, 2016). The area covered by forest ecosystems has increased in some regions due to agricultural abandonment and depopulation in rural areas (Plieninger *et al.*, 2014; Rolo and Moreno, 2019). The expansion of forest ecosystems provides more land that can be grazed and browsed by large domestic and wild herbivores (Papanastasis *et al.*, 2008; Rogosic *et al.*, 2006). This expansion of forest ecosystems, coupled with a growing demand for bovine meat, has generated interest in using Mediterranean woodlands for cattle foraging as an alternative to the limited herbaceous rangelands (Schoenbaum *et al.*, 2018). Despite the increase in woodland areas, a net decrease in forest pastures has been observed in the Northern Mediterranean countries over the past few decades. This decline is mainly due to the abandonment of low productivity areas (Fortuny, Carcaillet and Chauchard, 2020).

Cattle grazing and browsing have varied impacts on the environment and can affect the ecosystem services provided in several ways. Grazing can influence species recruitment by selectively targeting the most palatable seedlings and saplings (Plieninger *et al.*, 2014). Additionally, trampling and debarking can affect seed dispersal (Gill and Beardall, 2001), while trampling can also affect biogeochemical fluxes and the turnover of organic matter (Fortuny, Carcaillet and Chauchard, 2020; Lecomte *et al.*, 2019; McEvoy, Flexen and McAdam, 2006). Conversely, livestock grazing and browsing can have positive effects on the environment. For example, browsing by goats can increase the spatial heterogeneity of the vegetation structure and reduce the amount of inflammable material, thereby lowering the risk of wildfires (Schoenbaum *et al.*, 2018; Teruel-Coll *et al.*, 2019). The possible impacts are varied, indicating that they depend on many factors, including the forest plant species and community structure, the system's overall productivity, the specific grazing system, and ungulate density (Fortuny, Carcaillet and Chauchard, 2020; Ramirez, Jansen and Poorter, 2018). Effective population management can ensure the provision of ecosystem services and the preservation of ecosystem synergies (Gordon, Hester and Festa-Bianchet, 2004; Velamazán, Perea and Bugalho, 2020). However, the specific management strategy that should be implemented needs to be carefully considered, as trade-offs may arise in certain cases, such as between above-ground carbon storage and fire risk (Lecomte *et al.*, 2019), or between plant diversity and fire risk (Silva *et al.*, 2019; Velamazán, Perea and Bugalho, 2020).

Invasive non-native species of pests and pathogens

The accidental introduction of harmful non-native species of pests and pathogens has intensified with the growth of global trade and human mobility, greatly compromising the phytosanitary conditions of Mediterranean forests. These non-native species spread rapidly and trigger severe outbreaks in newly invaded areas, mainly due to the absence of natural predators and the higher susceptibility of host plants that have not co-evolved with them. Such species invasions can severely affect forest ecosystems and lead to major economic losses and social challenges.

In Portugal, European chestnut *Castanea sativa* is highly susceptible to *Phytophthora cinnamomi*, the causal agent of ink disease. Due to its high impact in chestnut forests, breeding programmes aimed at improving ink disease resistance in chestnut stands are underway, using resilient Asian *Castanea* species as resistance donors. Chestnut blight, a lethal disease caused by the pathogenic fungus *Cryphonectria parasitica*, is well established and widespread in Portugal, but in some stands, biological control using hypovirulent strains of *C. parasitica* is effective against the disease and improves chestnut recovery. A more recently introduced invasive species affecting chestnut trees in Portugal is the Asian chestnut gall wasp *Dryocosmus kuriphilus*, which has been present in mainland Portugal and the Madeira Islands since 2014 but is now effectively controlled by its introduced natural predator, *Torymus sinensis*. The pinewood nematode *Bursaphelenchus xylophilus* is the causal agent of pine wilt disease and an important mortality agent of pine forests in Portugal. Native to North America, this nematode was introduced in the Iberian Peninsula, where it mainly affects maritime pine (*Pinus pinaster*), resulting in high mortality rates and compromising the economic sustainability of these pine forests in northern Portugal. Also native to North America, *Fusarium circinatum* is an invasive pathogenic fungus responsible for pine pitch canker, one of the most serious threats to pines globally. In Europe, *F. circinatum* has been documented in Spain, Portugal, Italy and France, where it is a cause of mortality in various pine species, including *P. radiata, P. halepensis, P. pinaster* and *P. pinea*, mainly in nurseries but also in adult trees (*P. radiata* and *P. pinaster*) in northern Spain. This pathogen affects all stages of tree development, causing seed and seedling mortality and branch and stem dieback in young and mature pine trees.

Similarly, eucalyptus forest plantations in southwestern Europe have faced numerous health problems in the last decade. New invasive insect species from Australia, like the tortoise beetle *Trachymela sloanei* and the bronze bug *Thaumastocoris peregrinus* have caused concern. Meanwhile, the eucalyptus weevil *Gonipterus platensis*, established in the Iberian Peninsula since 1999, remains an ongoing concern, affecting more than 150 000 ha of land in northern and central Portugal. New wood-boring beetles have been discovered to attack *Eucalyptus globulus* in Portugal, namely *Amasa* sp., an Australian species also found in other European countries, and *Ambrosiodmus rubricollis*, which is native to eastern and southern Asia. Additionally, wood-borers like *Phoracantha semipunctata* and *P. recurve,* which have been present in southwestern Europe for some time, are causing increasing damage to eucalyptus plantations, especially in areas facing water stress or after very dry years. Fungal diseases caused by *Mycosphaerella* spp. and *Teratosphaeria* spp. on leaves, such as *T. gauchensis*, as well as *Quambalaria eucalypti*, which causes canker diseases, further contribute to the challenges facing eucalyptus plantations. Furthermore, five new fungal pathogen species of *Neopestalotiopsis* associated with *Eucalyptus* spp. were recently described in Portugal. Additionally, the association of *E. globulus* with *Phytophthora alticola* was observed for the first time outside South Africa.

In umbrella pine *Pinus pinea*, the conifer seed bug of North American origin, *Leptoglossus occidentalis,* is a major concern for the region's producers of pine nuts, a non-timber forest product of high economic value obtained from *P. pinea*. This invasive pest has been associated with young cone mortality, and in some areas, with seed losses of up to 20 percent. In Portugal, new diseases caused by fungal pathogens were found to be affecting *P. pinea*, particularly needle blight caused by *Dothistroma septosporum* and *D. pini*, and brown spot needle blight caused by *Lecanosticta acicola.*

In Spain, invasive insects and pathogens have greatly affected forests in the last 10 years, and there have been new introductions. *Leptoglossus occidentalis* has been present in conifers in Spain since 2003, but in 2012, it reached the main production areas for pine nuts. As elsewhere in the Mediterranean basin, the introduction of the insect species in the area coincides with reduced yields of pine nut crops, known as "dry cone syndrome". The Asian chestnut gall wasp *Dryocosmus kuriphilus* was detected in 2012, but caused the most damage from 2017 to 2021, with a substantial reduction in the production of chestnut fruit. However, since the introduction of its natural predator, *Torymus sinensis*, the pest population has decreased. *Buxus sempervirens* and *B. balearica* (the latter a species endemic to the Balearic Islands) in parks, gardens and forests have incurred severe damage from *Cydalima perspectalis*, which was first detected in 2014. In eucalyptus plantations, *Gonipterus platensis* continues to cause considerable defoliation. The damage has been reduced since the introduction of the biological control agent *Anaphes nitens*, but economic losses of EUR 234 697 have been recorded annually along the Cantabrian Coast. Palm trees are being seriously threatened by *Rhynchophorus ferrugineus*, which caused extensive damage in the Mediterranean between 2004 and 2009, with losses estimated at EUR 160 000. Today, this species continues to spread, currently inflicting substantial damage in the northwest and completely killing off palm trees in parks and gardens. Also in palm trees, *Paysandisia archon* continues to cause damage along the Mediterranean coastline and in the Balearic Islands, the Community of Madrid and the Canary Islands. Other invasive insects have recently been detected in the country, such as *Trachymela sloanei* (in 2014), *Thaumastocoris peregrinus* (in 2015), *Xylosandrus compactus* (in 2018), which affect more than 225 forest, agricultural and ornamental plant species, and *Corythucha arcuata* (in 2022), which feeds on oak trees. Their potential impact is still unknown.

Among the pine pathogens, *Mycosphaerella pini* and *M. dearnessii* caused serious damage in the north of the Iberian Peninsula, especially in radiata pine plantations in the Basque Country, Cantabria and Galicia. In the same area, outbreaks of *Fusarium circinatum* were detected, some of which have been eradicated, while others are in the process of eradication, mainly in forest plantations or nurseries. *Bursaphelenchus xylophilus* was detected in three different areas along the border with Portugal. In each case, a contingency plan was activated, and three demarcated areas were established. These areas are being intensely monitored, and trees that have been identified as positive have been removed. *Cryphonectria parasitica* which causes chestnut blight, continues to expand throughout Spain, causing serious damage to the chestnut trees, especially in northern areas. *Ophiostoma novo-ulmi* continues to affect many elm trees and saplings in central and eastern Spain. *Phytophthora cinnamomi* is responsible for the high mortality of chestnut trees in the northern and northwestern parts of the country, especially in wet years, and considerable damage was reported in 2018 and 2019. This species is also responsible for severe damage to cork oaks and holm oaks in central and southern Spain. *Phytophthora alni* was first detected in 2010 and has caused serious damage to alders along northwestern rivers, inducing high mortality in *Alnus* trees. *Phytophthora ramorum* is present in different Spanish localities but always associated with ornamental plants (*Rhododendron* spp. and *Camellia* spp.).

Over the past 10 years, Mediterranean forests in France have been at risk from several newly introduced organisms. Among invasive insect species are two Asian ambrosia beetles, *Xylosandrus crassiusculus* and *X. compactus*, first reported in 2014 and 2016 respectively. Their host range includes more than one hundred tree species in their native areas. For example, *X. compactus* has been found mainly on carob trees, oaks, *Arbutus*, bay trees and several ornamental tree species, while *X. crassiusculus* has been found almost exclusively on carob trees. New insect pest arrivals also include the oak lacebug *Corythucha arcuata* in 2017, the Asian wood-borer *Xylotrechus chinensis* in 2018 on *Morus* spp., and the pine tortoise scale *Toumeyella parvicornis* in 2021.

In addition to these new arrivals, several old invasions of pests and pathogens are still causing serious damage to Mediterranean forests. These include the longhorn beetle *Xylotrechus stebingi*, which feeds on oak, poplar and ash species, and the weevil *Gonipterus scutellatus*, the psyllid *Gycaspis brimblecombei* and the Australian longhorned beetles *Phoracantha semipunctata* and *P. recurva*, which feed on *Eucalyptus* spp. Moreover, chestnut trees are still affected by old invasions, such as *Cryphonectria parasitica* responsible for chestnut blight, and two oomycetes, *Phytophthora cambivora* and *P. cinnamomi*, responsible for chestnut root rot. The Asian chestnut gall wasp *Dryocosmus kuriphillus*, is also present, but its impact has diminished over the past 5 years thanks to the introduction of the biocontrol agent *Torymus sinensis* and to the presence of native parasitoid communities. Longstanding invasions include the scale insect *Matsucoccus feytaudi* on pines, the seed wasp *Megastigmus rafni* on firs, and the moth *Cydalima perspectalis* on *Buxus* spp. Among non-native vertebrates, the red-bellied tree squirrel (*Callosciurus erythraeus*, also known as the Pallas's squirrel) can cause damage to the seeds and bark of several forest tree species, primarily in urban and suburban areas.

In Italy, maritime pine *P. pinaster* along the Tyrrhenian coastline continues to experience attacks from the invasive scale insect *Matsucoccus feytaudi*, a species native to the northwestern African coast and southwestern Europe. This pest has almost destroyed the pine forests of the northeastern Mediterranean coastline, and the species is currently spreading southwards. Another serious threat to pines, currently to *P. pinea*, is the scale insect of Nearctic origin, *Toumeyella parvicornis*, which has spread rapidly northwards, devastating coastal pine forests after being first reported in 2015 in southern regions of Italy. This species has now reached the Tuscany region. On broadleaved trees, it is also worth mentioning the widespread drying-out of elms caused by fungi of the *Ophiostoma* genus. An increase in ink sore infections (*Phytophthora* spp.) and blight on chestnut trees has been reported in recent years.

Furthermore, Italian coastal pine forests continue to be affected by another scale insect, *Marchallina hellenica*, originating from the Greek islands of the Aegean Sea. This pest has been present in southern Italy for some time, on the island of Ischia, but is now causing outbreaks in other parts of the country, mainly attacking *P. pinea* and *P. halepensis*. Forest stands of *Cupressus sempervirens* are being damaged by the bark beetle *Phloeosinus armatus*, which originates from the eastern Mediterranean coastline and was first reported in Italy in 1991. This pest is progressively spreading to the central part of Italy, and severe outbreaks have been found on *Cupressus* spp. and on *Thuya occidentalis* and *Juniperus communis*. The damage caused by the North American species *Leptoglossus occidentalis* in coniferous forests should also be mentioned, given the substantial decline of pine nut production from *P. pinea*. In recent years, chestnut stands have also been affected by the Asian chestnut gall wasp *Dryocosmus kuriphilus*, but the introduction and spread of its natural predator *Torymus sinensis* have reduced the pest population, like in other Mediterranean countries in Europe. Additionally, a resurgence of *Cryphonectria parasitica* causing chestnut blight was observed recently in parts of the Italian peninsula.

In Greece, the Asian chestnut gall wasp *Dryocosmus kuriphilus* infested cultivated and natural chestnut stands soon after its introduction in 2014, but the systematic release of its natural predator *Torymus sinensis* has put the pest population under control. The mulberry wood-borer *Xylotrechus chinensis* has spread uninhibited since 2018, when it was first recorded in Greece. The red palm weevil *Rhynchophorus ferrugineus* has almost extinguished cultivated palm trees all over the country in less than 20 years. This pest is currently threatening the natural stands of endemic Cretan date palm species.

In Lebanon, only a few non-native species are currently considered harmful: the western conifer seed bug *Leptoglossus occidentalis* affecting seeds and cones of pine species, *Cameraria ohridella* harming *Acer* species and the black twig borer *Xylosandrus compactus* damaging oaks, carobs and other trees all pose a threat to forest tree species.

Until recently, invasive pests have had minimal impact on natural Mediterranean forests in Israel. Deterioration of *Eucalyptus* stands was associated with infestations by longhorn beetle *Phoracantha* spp., and stressed trees in *Ceratonia siliqua* stands were affected by the bark beetle *Euwallacea denticulus*. However, the establishment of the black twig borer *Xylosandrus compactus* serves as a warning sign, as it is a threat to several plant species.

In Algeria, the main invasive species affecting forest stands are those related to *Eucalyptus* stands, such as *Phoracantha semipunctata*, *P. recurva, Leptocybe invasa, Ophelimus maskelli, Gycaspis brimblecombei* and *Blastopsylla occidentalis*. *Leptoglossus occidentalis* is detrimental to cone and seed production in *P. pinea*, and *Deudorix livia* is harmful to *Acacia farnesiana*. *Dactylopius opuntia* is a pest of cacti (*Opuntia* spp.). This species, reported in Tlemcen, western Algeria, in 2021, has spread rapidly and widely, causing fruit deformation and wilting in infected plants.

Invasive pathogens that mainly damage cypress trees include *Seiridium cardinale, Pestalotiopsis* cf. *funerea* and *Botryosphaeria* cf. *dothidea*, which cause canker on trees. *Trabutia quercina* specifically targets oak species, causing a disease commonly known as tarry leaf spot, while *Coryneum* cf. *modonium* (sexual form *Pseudovalsa modonia*) causes canker on branches and twigs. In pines, *Leptographium* sp., *Sphaeropsissa pinea* and *Fusarium circinatum* are responsible for pine tree dieback.

In addition, several invasive plant species pose a serious threat to native biodiversity in Algerian forests and interfere with natural forest regeneration. Examples include plants such as *Acacia melanoxylum* and *A. dealbata*, *Robinia pseudoacacia, Acer negundo, Ailanthus altissima* and *Gleditsia triacanthos*. Some of these, like *R. pseudoacacia* and *A. altissima* threaten Mediterranean forests in most countries.

Native pest and disease outbreaks and forest diebacks

Since native Mediterranean phytophagous organisms have co-evolved with their host plants, severe infestations of tree species should theoretically not occur. However, disturbances such as human interventions in forest management – including intensive forestry and monoculture practices – air pollution, forest fires and nutrient depletion, along with the effects of climate change and extreme weather events like droughts, floods and storms, can stress trees and make them more susceptible to pest outbreaks at the local level.

This vulnerability often results in severe damage to forests. For certain species, such as defoliators, devastating outbreaks can also occur in cycles.

In Portugal, the combination of drought stress and forest fires, along with the decline of pine trees caused by pine wilt disease, has greatly contributed to the local rise of large populations of bark beetles. The six-toothed pine bark beetle *Ips sexdentatus*, the Mediterranean pine engraver *Orthotomicus erosus* and the pine shoot beetles *Tomicus* spp. are responsible for considerable damage in pine forests, especially following forest fires. *Tomicus* spp. not only kill trees and spread blue-stain fungi (which reduce the quality of timber), but also feed on pine shoots, causing growth losses and deformations on live pine trees during severe infestations. As an example, the Mediterranean pine shoot beetle *T. destruens* is a highly aggressive pest that primarily infests pine species like *Pinus halepensis, P. pinaster* and *P. pinea*. Over the past decade, outbreaks have occurred in forests and plantations experiencing climate-induced stress, as well as in areas affected by fires. The pine cone moth *Dioryctria mendacella* is also found in association with pine trees in Portugal. It is one of the most common pests affecting pine cones, with its larvae causing damage to tissues and seeds. This damage can lead to deformations, abnormal growth, cone abortion and seed loss. Several native and established fungal pathogens, including *Sydowia polyspora, Thyriopsis halepensis, Diplodia sapinea, Pestalotiopsis* sp., *Truncatella* sp. and *Heterotruncatella* sp., are increasingly observed attacking *P. pinea* plantations and forests, resulting in shoot blight disease with tip dieback, needle discoloration and shoot death. Mediterranean evergreen oaks, such as *Quercus suber* and *Q. rotundifolia*, are vulnerable to the oak pinhole borer *Platypus cylindrus*, a serious pest affecting oak ecosystems across southwestern Europe and northern Africa. Historically, this ambrosia beetle primarily targeted weakened trees but now infests apparently healthy oaks of various ages. It poses a sizable threat to newly debarked and burnt oak trees, which are particularly attractive to this and other wood-boring beetles. In combination with pathogens, these beetles contribute to the decline of Mediterranean oak forests. Signs of acute oak decline are increasingly being observed in several countries and include symptoms such as necrotic lesions, extensive bleeding from the trunk and crown thinning, ultimately leading to the death of the tree. Phytopathogenic bacteria, such as *Brenneria goodwinii* and *Gibbsiella quercinecans* have recently been isolated from symptomatic *Q. suber, Q. rotundifolia* and other oak species, and may play a role in the decline of Mediterranean oaks. The fungus *Biscogniauxia mediterranea* is also commonly found, particularly in arid regions. The damage caused by the flathead oak borer *Coroebus undatus* on cork bark reduces the value of cork bark planks, leading to major economic losses for the cork industry. Damage varies greatly from stand to stand, and in some locations in Portugal, over 70 percent of the trees are affected by this pest.

In Spain, recent damage by native insects has been largely attributed to defoliators and wood-borers. The processionary moth *Thaumetopoea pityocampa* is a common threat to pine trees and caused extensive defoliation along the eastern coastline from 2016 to 2020. During the same period, *Lymantria dispar* attacked several *Quercus* species in the southeastern coastal areas, including the Balearic Islands. *Aglaope infausta* caused repeated defoliations in the northern third of the Iberian Peninsula between 2014 and 2017, especially affecting hawthorn, *Crataegus monogyna*. The chrysomelid *Altica quercetorum* has been a recurring problem in oak forests in northwestern areas, causing substantial damage in 2016. Other chrysomelid species, particularly *Phratora vulgatissima*, caused severe defoliation in *Salix* spp. in the northwestern regions of the country in 2013–2014 and 2019–2020, although the damage was restricted to areas experiencing water stress. Borer-related issues were primarily attributed to bark beetles, notably in eastern Catalonia and the Balearic Islands between 2017 and 2019, where they were exacerbated by drought conditions. In 2023, a serious outbreak of *Ips sexdentatus* occurred after a forest fire in the Sierra de la Culebra in the region of Castilla and León. Other notable borers include *Rhyacionia buoliana*, which causes recurrent damage to young plantations of *P. radiata*, and *Coroebus florentinus,* which has consistently attacked trees across the country, particularly *Quercus ilex*, with occasional effects on other *Quercus* species.

In Spain, fungal damage was particularly significant in coniferous forests. *Diplodia sapinea* caused severe damage to several pine species in 2014, and in 2016 and 2017 in Catalonia. *Siroccocus conigenus* caused only moderate injury during this period, except for an increase in damage along the eastern coastline in 2020 and 2021. *Thyriopsis halepensis* caused some damage in the northeast, particularly in Catalonia in 2016 and 2021. Mistletoe, *Viscum album*, has caused significant damage in various areas of the Iberian Peninsula, especially in the northeast. This semi-parasitic plant species causes considerable weakening of the infested trees, particularly during periods of water stress, creating favourable conditions for other pathogens to spread and kill the trees.

Mediterranean forests in France have been threatened by various native pests and pathogens, whose host trees had been weakened by repeated drought stress. These pests and pathogens include the two buprestids *Coroebus florentinus* and *C. undatus* on oaks; bark and wood beetles such as *Tomicus destruens, T. piniperda, Orthotomicus erosus and Pissodes* spp. on pines; and *Pityokteines vorontzowi, P. spinidens* and *P. curvidens* on firs. Lepidopteran defoliators such as *Thaumetopoea pityocampa* and *Lymantria dispar* caused typical cycles of severe damage, with the well-known gradation and retrogradation phases of these species. The spread of certain pest species has been exacerbated by the increased frequency of fires over the past decade (e.g. *Phaenops cyanea* in Aleppo pine stands), and extreme weather events may have triggered local outbreaks and further spread (e.g. the silver fir needle miner *Epinotia subsequana*). Among the pathogens, the needle-infecting fungi *Thyriopsis halepensis* and *Dothistroma* spp. were increasingly associated with the needle blight disease in Aleppo pine stands, while powdery mildews (*Erysiphe alphitoides* and *E. quercicola*) predominantly occurred in oak stands. A wide range of wood pathogens have had substantial effects on pines (*Phellinus pini, Diplodia sapinea, Sclerophoma pithyophila, Crumenulopsis sororia* and *Cronartium flaccidum*), oaks (*Biscogniauxia mediterranea, Diplodia corticola*) and junipers (*Gymnosporangium* spp.). Pine root disease was mainly caused by the fungi *Heterobasidion* spp., *Armillaria* spp. and *Phytophthora* spp. Interestingly, mistletoe seems to be the only semi-parasitic plant posing a threat to French Mediterranean forests.

Over the past 10 years, attacks by native pests and pathogens have been reported on various tree species across Italy. Some pests are well known for their recurring population outbreaks, such as the oak defoliators and *Lymantria dispar*, which has affected several thousand hectares on the island of Sardinia. The defoliation prompted the decline of stands of cork oak *Quercus suber*, with the establishment of other organisms encouraged by the physiological stress that extreme weather events caused the trees to endure. Similarly, the *Tomicus* bark beetles have attacked mountain and submountain pine forests of *Pinus sylvestris, P. laricio and P. nigra*, and coastal pine forests of *P. halepensis, P. pinaster* and *P. pinea*. Oaks, especially *Q. ilex*, have been attacked by the longhorn beetle *Cerambyx cerdo*. This is especially concerning as the species is endangered and protected by the Habitat Directive, although it is observed locally to be highly abundant in coppice forests. Coniferous forests are the most threatened in Italy, and pines have been defoliated by *Thaumetopoea pityocampa*, whose infestations have been reported at higher altitudes and latitudes, particularly during mild winters. Widespread desiccation of elm trees caused by *Ophiostoma* fungi is noteworthy among broadleaved species. In recent years, there has also been an increase in reports of chestnut blight.

The pine processionary moth belonging to the *T. pityocampa* species complex is one of the most important and notorious insect pests in the forests of Greece. Mild winter temperatures exacerbate their impact on the physiology of pine trees by making them more susceptible to secondary pests. The urticating hairs of this moth's larvae pose a serious problem, especially in suburban forests that are often visited by the public. Warmer winters have also increased the impact of bark beetles. Outbreaks of the silver fir bark beetle *Pityokteines curvidens* in fir stands, as well as the pine shoot beetle *Tomicus destruens* and the engraver pine beetle *Orthotomicus erosus* are emerging with greater frequency and severity, resulting in substantial damage to conifer stands. *Lymantria dispar* is associated with more frequent and intense population outbreaks in kermes oak stands, often spreading to nearby cultivated broadleaf trees.

The main insect pests causing substantial damage to Lebanese forests include the pine processionary moth *T. wilkinsoni*, the sponge moth *L. dispar*, the cedar sawfly *Cephalcia tannourinensis* and the bark beetle *T. destruens*, along with other bark beetles of minor importance. In addition to these pests, there have been occasional outbreaks involving limited expansion of the following species: *Thaumetopoea* sp. and *Phyllonorycter libanotica* on oak, and T. *libanotica* and *Dichelia cedricola* on *Cedrus libani*.

In Israel, an outbreak of bark- and wood-borers, exacerbated by drought stress, affected approximately 120 ha of coniferous forests, primarily consisting of pine trees and *Cupressus sempervirens*, from 2020 to 2024. The main losses were caused by pine bark beetles, particularly *Orthotomicus erosus*, which inflicted severe damage on *P. halepensis* and *P. brutia*. *Pityogenes calcaratus* also had a notable impact on the canopies of *P. pinea*. Additionally, stands of the carob tree *Ceratonia siliqua*, mainly located along roads, suffered severe damage from rats (*Rattus rattus*). New outbreaks of *Matsucoccus josephi* were observed over an area of approximately 3 000 ha, predominantly in fire-regenerated pine forests. *Thaumetopoea wilkinsoni* affected an average area of 6 000 ha of pine stands annually during 2020–2024. A small area of *Cupressus sempervirens*, about 50 ha, is currently affected by the fungus *Diplodia cupressi* as a result of drought stress. The flat beetle *Steraspis squamosa* is posing varying levels of threat to drought-stressed *Tamarix* stands over an area of 200 ha, while wood-borers, particularly *Mesoprionus besikanus*, are attacking mature trees of *Quercus calliprinos*. Fragmented and scattered small populations of *Thaumetopoea solitaria* can be found in *Pistacia* stands, with severely infested areas covering approximately 1 000 ha. An increase in the population density of the moth was observed between 2020 and 2024. Actions taken to restrain *T. solitaria* populations are limited, only covering about 30 ha of recreational sites, despite the rising number of injuries to forest users caused by this moth.

Algeria's forests, which cover approximately 4.1 million ha, are mainly composed of Aleppo pine (*P. halepensis*), cork oak (*Quercus suber*), Zen and Afarès oak, *Eucalyptus* spp., maritime pine (*P. pinaster*) and Atlas cedar (*Cedrus atlantica*). Over the past 10 years, these forests have experienced extreme weather conditions, including prolonged droughts that have adversely affected tree growth and natural regeneration, particularly among forest stands located at the southernmost latitudes, such as the cedar and pine forests of the Saharan Atlas. Insects and fungi are among the biotic factors that damage the forests. Insects such as *Thaumetopoea pityocampa* on *Pinus* sp. and *C. atlantica, T. bonjeani* on *C. atlantica, Rhyacionia buoliana* on *P. halepensis, Lymantria dispar* on *Q. suber* and *Q. ilex,* along with wood-boring insects such as *T. destruens and O. erosus* on *Pinus* sp., *Phaenops marmottani* on *C. atlantica, Platypus cylindrus* on *Q. suber*, are all involved in the dieback of their host species. Among all these insects, the pine processionary moth *T. pityocampa* is the most widespread and aggressive species, causing significant damage to natural Aleppo pine and Atlas cedar forests, with an average annual infestation exceeding 60 000 ha. The cork oak forests have been severely affected by an outbreak of charcoal disease since 2022, caused by *Biscogniauxia mediterranea*. The disease has been reported in 60 percent of cork oak trees, indicating that it is likely widespread throughout their range. It has caused the death of extensive areas of cork oak forest, particularly those that have experienced wildfires or prolonged water stress.

Concluding remarks

This chapter highlights that the nature, intensity and impacts of degradation drivers in Mediterranean forests differ across the region owing to the contrasting dominant conditions in Northern, Southern and Eastern Mediterranean countries, which arise from social, economic and environmental differences (Bernués *et al.*, 2011; Malek *et al.*, 2018; Wright and Cafiero, 2011). As a result of these differences, the same driver of degradation can have contrasting effects: for example land abandonment in the northern part of the Mediterranean can lead to rewilding and increased forest cover, while in the south, it can lead to soil degradation and desertification (Bentley and Coomes, 2020; Ruiz-Flaño, García-Ruiz and Ortigosa, 1992; Sluiter and De Jong, 2007; Stoate *et al.*, 2009; Ustaoglu and Collier, 2018; van der Zanden *et al.*, 2017). Moreover, other drivers of degradation such as pathogens and pests are often species-specific, and therefore, their impact will vary across countries based on the presence and abundance of target tree species and the specific pathogen or pest. However, factors like climate change have a broader impact across the region. In the Mediterranean, climate change has resulted and will continue to result in warmer and drier conditions, increasing the severity of extreme weather events such as heatwaves and droughts (MedECC, 2020). Although there are intrinsic differences and reported geographical variations across the region, all the drivers of degradation analysed in this chapter are projected to worsen, leading to more severe impacts. Urgent action is needed to effectively address these issues and ensure the conservation of Mediterranean forests and the ecosystem services they provide.

In this context, practices that contribute to forest conservation and increase the resilience of forests to changing environmental conditions, such as adaptive forest management, are of paramount importance. Implementing adaptive management strategies that promote diverse species composition – favouring tree species and provenances better adapted to changing conditions and environmental stress – along with integrated pest management, controlled grazing and prescribed burning can provide a multifaceted approach to safeguarding forest ecosystems and securing the conservation of biodiversity at all levels, including at the ecosystem, species and genetic level. With close monitoring, early detection and targeted interventions, forest managers can effectively limit the establishment and spread of invasive species, as well as the occurrence of wildfires, thereby safeguarding the integrity of forest habitats. Forest conservation, adaptive management and monitoring in the Mediterranean could benefit from the application of regional and international strategies. These strategies should capitalize on shared threats while considering the unique differences among countries – such as in environmental conditions, political landscapes, economic structures and societal norms – that could be assets in tackling the complex and interconnected threats facing the region. Collaborative, transnational systems-based and holistic approaches can help address complex problems spanning borders and affecting large areas, such as climate change (Bou Dagher Kharrat *et al.*, 2022). These approaches can serve as a foundation for protecting Mediterranean forests and the ecosystem services they provide.

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Chapter 4
Forest and landscape restoration initiatives in the Mediterranean region

Valentina Garavaglia,[1] Giovanbattista de Dato,[1] Anne Maud Courtois,[1] Andrea Romero Montoya,[1] Cristiane Sater Melnik,[1] Young Kim,[1] Christophe Besacier,[1] Diana Colomina,[2] Jordi Cortina-Segarra,[3] Maria Melero,[2] George Gann,[4] Bethanie Walder,[4] Alessandra Sensi[5]

[1] Food and Agriculture Organization of the United Nations, Rome, Italy

[2] Forest Programme, WWF Spain, Madrid, Spain

[3] Department of Ecology and Multidisciplinary Institute for Environmental Studies (IMEM), University of Alicante, Spain

[4] Society for Ecological Restoration (SER), Washington, DC, United States of America

[5] Union for the Mediterranean, Barcelona, Spain

Forest and landscape restoration principles and their application in the Mediterranean region

Forest and landscape restoration (FLR) has been practised for nearly 20 years, since the time when reforestation and tree planting were considered in terms of industrial plantations and small-scale community woodlots (Laestadius and Buckingham, 2015). Thanks to the growing attention on and more systematic assessments of deforestation and forest degradation, FLR has shifted from a focus solely on forests to include the degradation of non-forest ecosystems as well. Forest and landscape restoration practices now employ a landscape approach that aims to balance environmental and socioeconomic needs.

Forest and landscape restoration is fully embedded in the international framework, and is gaining momentum at the global level and being promoted through the United Nations Decade on Ecosystem Restoration 2021–2030 (the "UN Decade"). Forest and landscape restoration is fully supported by international organizations and agencies as a means of achieving the United Nations 2030 Agenda for Sustainable Development, the nationally determined contributions of parties to the Paris Climate Agreement, the New York Declaration on Forests and the Bonn Challenge, which aims to restore 350 million hectares (ha) of degraded land by 2030. Initiatives based on FLR are underway at the global, local, national and regional levels in Africa, Asia, Latin America and the Mediterranean region.

The Mediterranean region's long history of human activity and distinct climate have led to plant adaptations to factors such as land clearing, grazing, wildfires and drought. Throughout history, the people of the Mediterranean region have attempted, with varying degrees of success, to strike a balance between the use of forest resources and their conservation. Today, despite some economic progress, they are facing significant socioeconomic, environmental and land-use challenges. The Mediterranean region thus presents both a unique challenge and an opportunity for scientists, and natural resources and forest managers, because of its complex environmental and anthropological history (Scarascia-Mugnozza *et al.*, 2000).

Mediterranean ecosystems are experiencing intensified land use, urban development and climate change, which have led to degraded lands with reduced provision of ecosystem services, low biological productivity and slow recovery rates after disturbances or abandonment (MedECC, 2020). Restoring degraded Mediterranean ecosystems is the main means by which to reverse land degradation and restore the composition, functioning and sustainability of these ecosystems, and to contribute to improving the livelihoods and well-being of local populations (Nunes *et al.*, 2016).

In the first half of the twentieth century, many restoration projects relied on a silvicultural approach that focused on monospecific tree stands, resulting in low diversity. This restoration practice has gradually been replaced by a more holistic approach that incorporates a diverse range of interventions, land uses and plant species. Regional actors are promoting forest restoration with a strong research-based approach that emphasizes participatory planning, enhanced engagement of local communities — with particular attention to including women and youth — and greater efforts to mobilize both public and private resources (FAO, 2024). Although the available data are still limited, evidence shows that the costs and benefits vary widely across and within different forest restoration options. Nearly all restoration approaches, however, are considered financially viable (Pacheco *et al.*, 2024; Bodin *et al.*, 2022). Consequently, restoration has been increasingly integrated into national policies and regional commitments, with a rise in initiatives aimed at securing the resources needed for effective implementation. In 2018, members of the Global Partnership on Forest and Landscape Restoration (GPFLR), a group of high-level international organizations involved in FLR policy and implementation, proposed six principles that capture the essence of FLR (Table 4.1) and reflect a shared understanding of the concept. These principles outline a holistic approach designed to encourage consistent practices on the ground. They have served as the foundation for developing operational frameworks that guide effective practices (Besseau, Graham and Christophersen, 2018). More recently, as part of the UN Decade, the Taskforce on Best Practices, established under FAO's leadership to advance knowledge dissemination and capacity-building efforts, has developed principles (FAO, IUCN CEM and SER, 2021) and standards of practice (Nelson *et al.*, 2024) to guide ecosystem restoration. These guidelines aim to help practitioners maximize the ecological, cultural and socioeconomic benefits of their restoration activities (Figure 4.1 and Figure 4.2).

In the Mediterranean region, the growing interest in FLR culminated in 2017 in the endorsement of the Agadir Commitment. This regional commitment, announced during the Fifth Mediterranean Forest Week in Agadir, Morocco, aims to restore 8 million ha of degraded Mediterranean forests by 2030. The initiative contributes to global efforts such as the Bonn Challenge, Sustainable Development Goal 15, the Kunming-Montreal Global Biodiversity Framework (GBF), and the goal of achieving land degradation neutrality. Numerous regional partners, including FAO, the French Facility for Global Environment (FFEM), the German International Climate Initiative (IKI), the European Forest Institute's Mediterranean Facility (EFIMED), the Mediterranean Model Forest Network (MMFN), the Union for the Mediterranean (UfM), and the United Nations Environment Programme (UNEP), are providing both technical and financial support to regional actions and projects. These efforts are part of a broader strategy aimed at addressing pressing issues, such as climate change, water scarcity and biodiversity loss in the Mediterranean region.

The efforts of Mediterranean countries to advance restoration at both national and regional levels were further strengthened by the adoption of the Antalya Declaration during the Seventh Mediterranean Forest Week in March 2022 in Türkiye. This declaration calls on countries and relevant stakeholders to intensify their restoration efforts and work together to address shared environmental and climate-related challenges.

This shows that, prior to the launch of the UN Decade and the designation of the region as a World Restoration Flagship, whose full title is

Table 4.1. Six principles of forest and landscape restoration according to the GPFLR

Main focus of principle	How the principle applies to FLR
1. FOCUS ON LANDSCAPES	FLR takes place within and across entire landscapes, not individual sites, representing mosaics of interacting land uses and management practices under various tenure and governance systems. It is at this scale that ecological, social and economic priorities can be balanced.
2. ENGAGE STAKEHOLDERS AND SUPPORT PARTICIPATORY GOVERNANCE	FLR actively engages stakeholders at different scales, including vulnerable groups, in planning and decision-making regarding land use, restoration goals and strategies, implementation methods, benefit sharing, monitoring and review processes.
3. RESTORE MULTIPLE FUNCTIONS FOR MULTIPLE BENEFITS	FLR interventions aim to restore multiple ecological, social and economic functions across a landscape and generate a range of ecosystem goods and services that benefit multiple stakeholder groups.
4. MAINTAIN AND ENHANCE NATURAL ECOSYSTEMS WITHIN LANDSCAPES	FLR does not lead to the conversion or destruction of natural forests or other ecosystems. It enhances the conservation, recovery and sustainable management of forests and other ecosystems.
5. TAILOR TO THE LOCAL CONTEXT USING A VARIETY OF APPROACHES	FLR uses a variety of approaches that are adapted to the local social, cultural, economic and ecological values, needs and landscape history. It draws on the latest science and best practice, and traditional and Indigenous knowledge, and applies that information in the context of local capacities and existing or new governance structures.
6. MANAGE ADAPTIVELY FOR LONG-TERM RESILIENCE	FLR seeks to enhance the resilience of the landscape and its stakeholders over the medium and long term. Restoration approaches should enhance species and genetic diversity and be adjusted over time to reflect changes in climate and other environmental conditions, knowledge, capacities, stakeholder needs and societal values. As restoration progresses, information from monitoring activities, research and stakeholder guidance should be integrated into management plans.

Source: Besseau, P., Graham, S. & Christophersen, T., eds. 2018. *Restoring forests and landscapes: the key to a sustainable future*. Vienna, Global Partnership on Forest and Landscape Restoration. https://www.iufro.org/publications/restoring-forests-and-landscapes-the-key-to-a-sustainable-future

"Restoration of degraded forest ecosystems as nature-based solutions to build resilience in the Mediterranean region," restoration efforts were already underway at the national and regional levels. Since the declaration of the UN Decade, the focus has been on encouraging countries to continue moving from commitments to effective action on the ground and more coordinated reporting. The World Restoration Flagship "Restoring Mediterranean Forests" was one of the World Restoration Flagships selected and officially announced at the Sixth Session of the United Nations Environment Assembly (UNEA) held in Nairobi in February 2024.It can inspire other countries and regions to scale up successful restoration efforts and attract global attention and investments.

Box 4.1.

Climate-resilient forest and landscape restoration based on selecting suitable tree species and seed sources

Tobias Fremout,[1] Evert Thomas,[1] Jean Stephan,[2] Melissa Korban,[2] Barbara Vinceti[3]

[1] Alliance of Bioversity & CIAT, Peru

[2] Lebanese University, Lebanon

[3] Alliance of Bioversity & CIAT, Italy

A significant portion of ongoing restoration efforts involve planting trees,[i] and choosing the most suitable tree species and seed sources is essential for meeting restoration objectives and local site requirements.[ii, iii] Selecting the right species has long-lasting ecological and economic implications, and factors like local stressors (e.g. eroded soils, fire risk) and adaptation to climate change should be taken into account.

Restoration practitioners often face challenges when integrating various knowledge fields and techniques into their decision-making processes about species selection and seed sourcing. As a result, they often rely on available, commonly used species, many of which are exotic. Decision-support tools have been developed to assist in selecting tree species and sourcing seeds, but they typically do not account for future climate scenarios.

An online decision-support tool called "Diversity for Restoration" (D4R)* has been developed[iv] to help users select appropriate tree species and seed sources based on site location and conditions, restoration objectives and climate projections. This tool also provides guidance for propagation and monitoring.

D4R uses habitat suitability modelling, functional trait data, local ecological information and restoration objectives to identify species combinations and seed sourcing areas that promote biodiversity and enhance climate resilience. It also generates seed zone maps to help source planting material that is suited to current and future environmental conditions while filtering out species that are unsuitable for these conditions.[v] The tool is accessible, scalable and beneficial for a wide range of stakeholders.

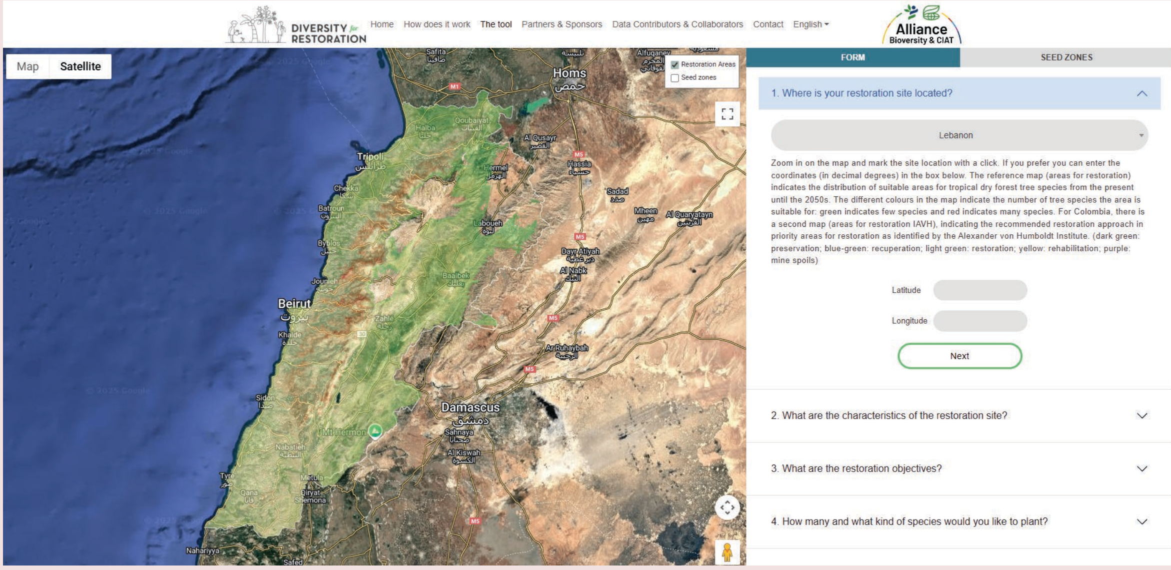
D4R is user-friendly and can be used by a variety of stakeholders, including restoration project managers, non-governmental organizations (NGOs), local governments and scientists, for tree planting initiatives, regardless of the specific restoration approach. The tool has been developed for various regions, with expansion plans for other areas.

D4R for Lebanon

Lebanon has experienced considerable deforestation and forest degradation over the years due to factors including unsustainable logging, urban expansion and wildfires. This has led to a loss of biodiversity, reduced carbon sequestration and heightened vulnerability to landslides and soil erosion, and the endangerment of several native species. Like many other countries, Lebanon is vulnerable to the impacts of climate change. Healthy forests are vital for adapting to climate change as they stabilize soils, regulate water flow and provide habitats for various species. The country has recognized the importance of forest and landscape restoration[vi] and has undertaken various initiatives to tackle these issues. Ongoing efforts involve policy and legal frameworks, reforestation programmes, awareness campaigns, international partnerships, community engagement, and research on the spatial distribution modelling of forest tree species.[vii]

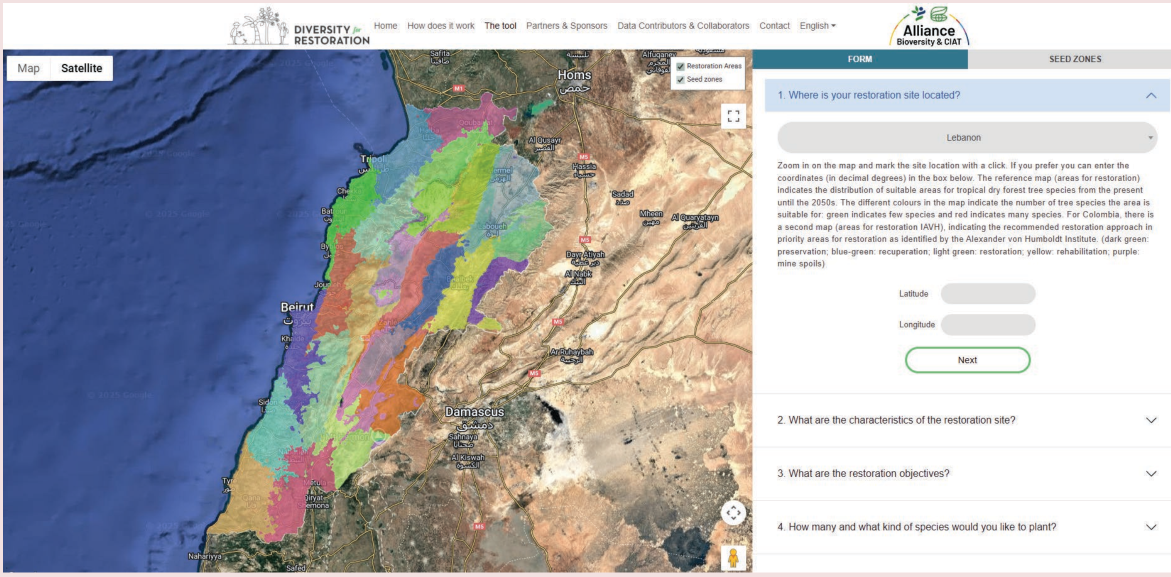
To support ongoing restoration efforts, a D4R module for Lebanon has been developed that incorporates species distribution models and information on the functional traits of 62 native tree and shrub species. The user receives recommendations on the best combinations of species to plant, and which seed zone to select for obtaining seeds.

Figure A. User interface of the D4R tool, showing the map of the country selected and other simple user inputs that define the planned restoration initiative



Note: Refer to the disclaimer on page ii for the names and boundaries used in this map.

Figure B. User interface of the D4R tool showing the seed zones generated using a dynamic modelling approach, based on ecoregions and their expected variations under different climate scenarios



*Notes: * See https://www.diversityforrestoration.org/ . Refer to the disclaimer on page ii for the names and boundaries used in this map.*

Sources:

i Brancalion, P.H.S. & Holl, K.D. 2020. Guidance for successful tree planting initiatives. *Journal of Applied Ecology*, 57(12): 2349–2361. https://doi.org/10.1111/1365-2664.13725

ii Atkinson, R.J., Thomas, E., Roscioli, F., Cornelius, J.P., Zamora-Cristales, R., Franco Chuaire, M., Alcázar Caicedo, C. *et al.* 2021. Seeding resilient restoration: An indicator system for the analysis of tree seed systems. https://doi.org/10.3390/d13080367

iii Thomas, E., Alcázar, C., Moscoso Higuita, L.G., Osorio, L.F., Salgado Negret, B., González, M., Parra, M. *et al.* 2017. The importance of species selection and seed sourcing in forest restoration for enhancing adaptive potential to climate change: Colombian tropical dry forest as a model. In: L. Rodríguez & I. Anderson, eds. *The Lima Declaration on Biodiversity and Climate Change: Contributions from Science to Policy for Sustainable Development*. pp. 122–134. CBD Technical Series No. 89. Montreal, Canada, Secretariat of the Convention on Biological Diversity. https://hdl.handle.net/10568/90681

iv Fremout, T., Thomas, E., Taedoumg, H., Briers, S., Gutiérrez-Miranda, C.E., Alcázar-Caicedo, C., Lindau, A. *et al.* 2021. Diversity for Restoration (D4R): Guiding the selection of tree species and seed sources for climate-resilient restoration of tropical forest landscapes. *Journal of Applied Ecology*, 59(3): 664–679. https://doi.org/10.1111/1365-2664.14079

v Fremout, T., Thomas, E., Bocanegra-González, K.T., Aguirre-Morales, C.A., Morillo-Paz, A.T., Atkinson, R., Kettle, C. *et al.* 2021. Dynamic seed zones to guide climate-smart seed sourcing for tropical dry forest restoration in Colombia. F*orest Ecology and Management*, 490: 119127. https://doi.org/10.1016/j.foreco.2021.119127

vi Amidi, J., Stephan, J.M. & Maatouk, E. 2020. Reforestation for environmental services as valued by local communities: a case study from Lebanon. *Forestry Economics Review*, 2(1): 97–115. https://doi.org/10.1108/FER-07-2019-0017

vii Stephan, J., Bercachy, C., Bechara, J., Charbel, E. & López-Tirado, J. 2020. Local ecological niche modelling to provide suitability maps for 27 forest tree species in edge conditions. *iForest - Biogeosciences and Forestry*, 13(3): 230. https://doi.org/10.3832/ifor3331-013

Figure 4.1. Ten principles developed to create a shared vision of ecosystem restoration for the United Nations Decade on Ecosystem Restoration 2021–2030

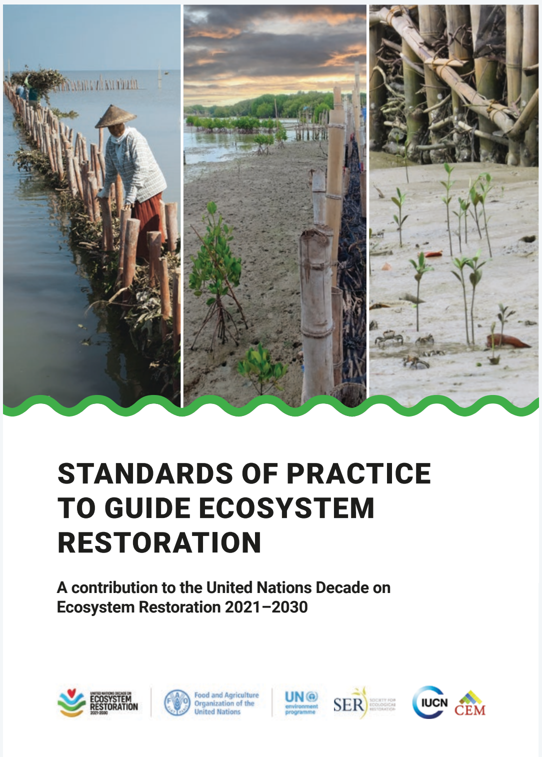
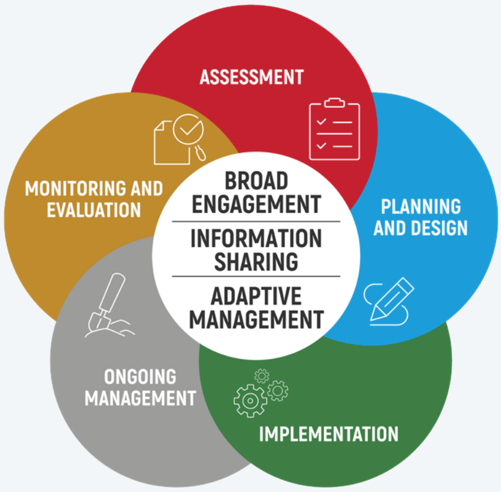


Figure 4.2. The *Standards of practice to guide ecosystem restoration* include over 300 recommended practices for application of the principles of the United Nations Decade on Ecosystem Restoration 2021-2030 throughout the restoration process



Notes: Recommended practices are organized into five components and multiple subcomponents of the restoration process. Practices associated with broad engagement, information sharing and adaptive management should be applied throughout the restoration process and therefore, have been included in cross-cutting subcomponents.

Source: Nelson, C.R., Hallett, J.G., Romero Montoya, A.E., Andrade, A., Besacier, C., Boerger, V., Bouazza, K. *et al.* 2024. *Standards of practice to guide ecosystem restoration – A contribution to the United Nations Decade on Ecosystem restoration 2021–2030*. Rome, FAO, Washington, DC, SER & Gland, Switzerland, IUCN CEM. https://doi.org/10.4060/cc9106en

The role of Mediterranean forest ecosystems in the global restoration scenario

This section focuses on the Mediterranean region's potential to play a key role in the international FLR framework and discusses the status of its restoration flagship.

The key role of the Mediterranean region in the context of the United Nations Decade on Ecosystem Restoration

In the Mediterranean region, multiple efforts have been made, even before the declaration of the UN Decade, to strengthen the enabling environment needed to promote and accelerate the restoration of forest ecosystems.

These include:

- the establishment of the **Collaborative Partnership on Mediterranean Forests (CPMF)** in 2010 to improve the adaptation and implementation of policies and strategies for sustainable forest management and ecosystem services, particularly in response to climate change (FAO, 2012);
- the adoption of the **Strategic Framework on Mediterranean Forests (SFMF)** and the **Tlemcen Declaration** in 2013 to provide policy guidelines for the integrated management of forest ecosystems within Mediterranean landscapes, including the restoration of degraded Mediterranean forest landscapes among its strategic areas (FAO, 2013);
- the endorsement of the **Agadir Commitment** in 2017 by nine Mediterranean countries to restore 8 million ha of degraded land by 2030 (FAO, 2017);
- the adoption of the **Brummana Declaration** in 2019 to strengthen sustainable forest management and the integration of forest

Box 4.2.
The United Nations Decade on Ecosystem Restoration 2021–2030

In 2019, the United Nations General Assembly proclaimed 2021–2030 to be the United Nations Decade on Ecosystem Restoration (the "UN Decade") under resolution 73/284. The UN Decade aims to accelerate and upscale efforts to prevent, halt and reverse the degradation of ecosystems worldwide by creating a global restoration movement, fostering political will and enhancing technical capacities across sectors.[i] Led by FAO and the United Nations Environment Programme (UNEP), the UN Decade contributes to global environmental objectives, including the 2030 Agenda for Sustainable Development, the Bonn Challenge, and the goals of the three Rio Conventions. The UN Decade is guided by a strategy[i] and an action plan[ii] and is supported by a robust governance structure comprising over 250 partners, five Taskforces, on Best Practices, Finance, Monitoring, Science and Youth, an Advisory Board and a Strategy Group.

Sources: [i] UNEP & FAO. 2020. *The United Nations Decade on Ecosystem Restoration – Strategy*. Nairobi and Rome. https://wedocs.unep.org/bitstream/handle/20.500.11822/31813/ERDStrat.pdf?sequence=1&isAllowed=y

[ii] UNEP & FAO. 2023. *Action Plan for the UN Decade on Ecosystem Restoration, 2021–2030*. Nairobi and Rome. http://www.decadeonrestoration.org/publications/action-plan-un-decade-ecosystem-restoration-2021-2030

ecosystem restoration into the nationally determined contributions of Mediterranean countries as part of their commitment under the Paris Agreement (FAO, 2019); and

- the endorsement of the **Antalya Declaration** in 2022 to increase restoration efforts, foster regional collaboration on shared environmental and climate-related challenges, and engage diverse stakeholders, including youth and the private sector (FAO, 2022).

The Nature Restoration Law was recently adopted to restore at least 20 percent of the European Union's land and sea areas by 2030, with the goal of restoring all ecosystems in need by 2050 (*Nature Restoration Law*, 2024, article 1, paragraph 2). This law presents a significant opportunity to upscale restoration efforts in the Mediterranean member states of the European Union. The regulation sets out rules for restoring ecosystems, habitats and species, to promote the long-term recovery of biodiverse and resilient nature, support

Box 4.3.

A structured approach for the post-fire restoration of black pine forests

Objective of the practice: Restore 290 hectares (ha) of the burnt priority habitat type, "Mediterranean pine forests with endemic black pine" by applying a structured approach that prioritizes burnt forest patches for restoration according to exclusion and ranking criteria. Key objectives include conserving pre-fire black pine forest areas, restoring and improving the habitat's conservation status, creating wildlife corridors between forest patches, and enhancing the forest's climate resilience through adaptive management.

Forest category: Mediterranean and Anatolian black pine forest

Country: Greece

Source: LIFE GoProFor Good Practices Database

Problems and threats addressed by the practice: In the summer of 2007, Greece experienced devastating wildfires that severely damaged key ecosystems, including black pine (*Pinus nigra*) forests. On Mount Parnonas, a designated Special Area of Conservation, 1 921 ha of black pine forest burned. While black pine can resist ground fires, it is highly vulnerable to crown fires and lacks the ability for widespread natural regeneration. Its scattered distribution on Parnonas further increased the risk of local extinction, especially in isolated patches where seed dispersal was unlikely. Following the fire, 11.09 percent of this priority habitat type was lost, mostly in its southernmost areas.

Best practice short description: This practice outlines a structured, step-by-step approach to post-fire restoration of *Pinus nigra* forests in Mediterranean areas, particularly where natural regeneration is unlikely. It begins with specifying exclusion and ranking criteria based on factors such as soil depth, slope, ecological importance and habitat type, followed by the ranking of areas for restoration. A preliminary selection of areas is then made, considering operational constraints like funding and accessibility, which is verified on site. Restoration measures, including seeding or planting, are chosen based on resource availability, with additional considerations for improving water availability and controlling grazing. The approach also includes post-implementation measures, such as maintaining seed stocks, silvicultural treatments, and ongoing monitoring to ensure long-term success.

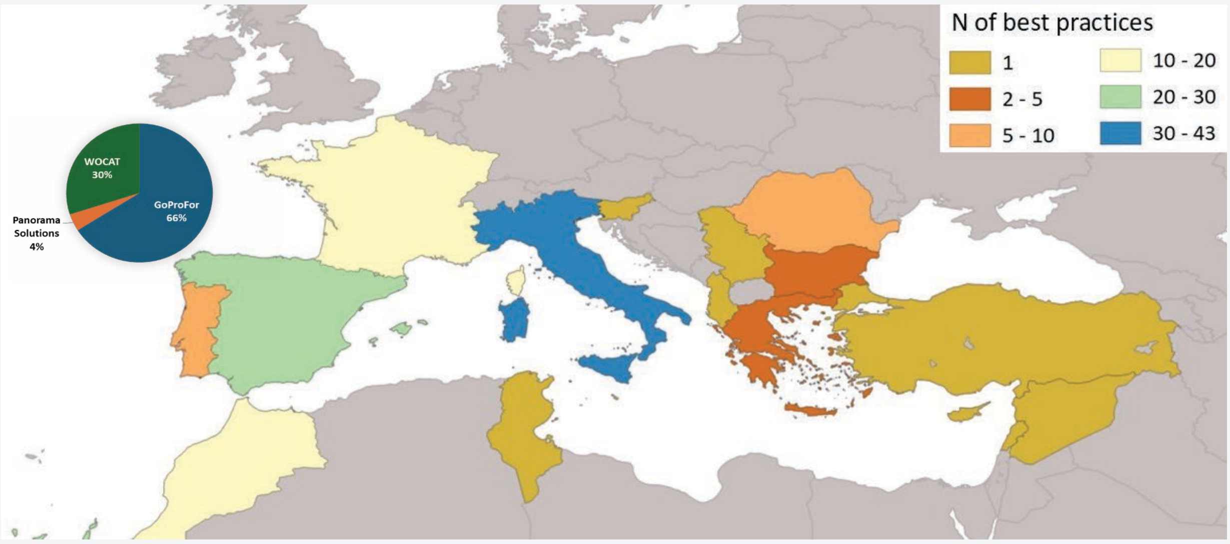
Note: For more information, see: https://www.lifegoprofor-gp.eu/best-practice/354/eng

Source: GoProFor. 2013. Forests and Nature 2000 Good Practices Database: LIFE+ PINUS – Restoration of the Pinus nigra Forests on Mount Parnonas (GR 2520006) through a structured approach. [Accessed on 26 May 2025]. https://www.lifegoprofor-gp.eu/best-practice/354/eng climate goals, enhance food security, and meet international commitments. Furthermore, the Nature Restoration Law establishes the European Union as the only region in the world with a legally binding framework for ecosystem restoration, providing a solid foundation for regional collaboration and action, particularly in the Mediterranean, which faces a range of pressing environmental challenges.

Substantial efforts have also been made in the region to enhance the capacities of practitioners through knowledge sharing. This is key to avoid repeating mistakes and to facilitate the replication and adaptation of successful FLR experiences. Some of these initiatives have been led by the LIFE Programme (short for the French L'Instrument Financier pour l'Environnement), MedForVal, Istituto Oikos, the European Forest Institute (EFI), and the UN Decade Taskforce on Best Practices coordinated by FAO. The latter has been closely collaborating with the UN Decade Taskforce on Monitoring (also led by FAO) to document and disseminate best practices through the Framework for Ecosystem Restoration Monitoring (FERM).

FERM serves as the official platform of the UN Decade for tracking global restoration progress and sharing best practices (also called "good practices"). It includes a search engine that connects users to approximately 2 000 best practices documented across various platforms, such as GoProFor, WOCAT, Panorama Solutions, and FERM itself. For the country members of the Committee on Mediterranean Forestry Questions – *Silva Mediterranea*, there are currently 151 best practices on forest restoration available for consultation through FERM (see the example in Box 4.3). Most of the documented cases are from Italy, Spain, Morocco and France (see Figure 4.3), covering topics such as the removal of invasive species, habitat restoration, fire prevention and post-fire restoration, soil protection, and sustainable land management. While these practices are invaluable, substantial efforts are needed to expand the FERM search engine by incorporating more best restoration practices, especially from the eastern and southern parts of the Mediterranean region. These efforts allow FLR activities in the Mediterranean to serve as global models for tackling complex environmental issues, such as the increasing risk of wildfires, forest and land degradation, and climate change.

Figure 4.3. Distribution of best practices for forest restoration, submitted in English, among country members of the Committee on Mediterranean Forestry Questions – *Silva Mediterranea*, available for consultation through the FERM common search engine



Notes: The chart pie indicates the platforms where the best practices were sourced.
Refer to the disclaimer on page ii for the names and boundaries used in this map.

Source: United Nations Geospatial. 2020. Map geodata [shapefiles]. New York, USA, United Nations.

Restoring Mediterranean Forests: a World Restoration Flagship of the UN Decade

To translate commitments into effective action on the ground, the UN Decade has launched calls for countries to nominate their World Restoration Flagships, which they consider to be the best or most promising restoration initiatives that reflect the UN Decade principles (FAO, IUCN CEM and SER, 2021) and could inspire others to undertake or upscale restoration. The flagships demonstrate successful restoration efforts and provide a model for addressing the interconnected crises of climate change, biodiversity loss and pollution.

As a result of the first call for flagships launched in 2022, the initiative "Restoring Mediterranean Forests" nominated by the Committee on Mediterranean Forestry Questions – *Silva Mediterranea* was subsequently selected and announced in 2024 as a World Restoration Flagship. This Mediterranean flagship is a comprehensive initiative that targets the entire Mediterranean region, with a specific focus on Lebanon, Morocco, Tunisia and Türkiye. These countries, which endorsed the Agadir Commitment in 2017, are central to the flagship's mission to scale up mosaic FLR through a regional development model that emphasizes the sustainable use of land and the conservation of natural resources to combat land degradation and the impacts of climate change.

One of the most significant impacts of climate change in the Mediterranean region is the increasing frequency, intensity and duration of wildfires (FAO and Plan Bleu, 2013, 2018). To address this threat, it is crucial to improve the capacity for restoring the ecological integrity of burnt areas that may not recover on their own after the fire, and for increasing their resistance and resilience to future wildfires. The region has already generated valuable knowledge and effective practices in this field, which should be systematically documented and shared to enable replication and scaling-up. Recognizing this initiative as a World Restoration Flagship has enabled targeted support to be directed at leveraging and sharing knowledge on post-fire restoration efforts among regional actors, building on the work of the UN Decade Taskforce on Best Practices to disseminate effective ecosystem restoration practices through FERM.

The goal is to help scale up effective restoration efforts by showcasing successful post-fire restoration practices that can be replicated in various locations beyond the four target countries. This approach fosters regional collaboration among country members of *Silva Mediterranea*, local communities and key partners. It also strengthens the political commitment to invest in joint efforts aimed at restoring resilient landscapes in areas prone to wildfires.

By scaling up restoration activities in line with the UN Decade principles, the Mediterranean flagship aims to maximize both ecological and socioeconomic benefits, facilitating the achievement of the pledges made under the Agadir Commitment and contributing to global restoration goals by 2030. The Mediterranean region is exemplary in its efforts to develop and sustain the restoration movement, foster political will and commitment, facilitate knowledge sharing, and achieve tangible results on the ground. These efforts hold great potential for learning, replication and scalability. They are pivotal contributions to the UN Decade and position the Mediterranean region as a key player in the global restoration agenda.

Status of restoration in the region: data availability and gaps

The need to assess restoration progress

Assessing the progress of restoration in the Mediterranean region is critical for understanding the status of initiatives to combat land degradation and restore forests and landscapes, particularly in light of the Agadir Commitment, which aims to restore 8 million ha of degraded Mediterranean forests by 2030. However, a comprehensive evaluation of the region's restoration efforts reveals a mixed picture. While there has been notable progress in some areas, there are still significant challenges related to data availability, consistency and reporting.

At the Twenty-Fourth Session of *Silva Mediterranea* held in Antalya, Türkiye, in 2022, members agreed to conduct an intermediate assessment of the Agadir Commitment's status 5 years after its endorsement in 2017. This assessment drew on a variety of sources, including the expertise of *Silva Mediterranea* national focal points and regional experts, who provided support for data collection and the validation of data gathered from reports on restoration projects carried out throughout the Mediterranean region between 2017 and 2022 (De Dato *et al.*, 2024). Papers published in indexed journals were also reviewed (Austin *et al.*, 2020; Roe *et al.*, 2021), which aggregated data on areas under afforestation and restoration in Mediterranean countries.

Despite these various sources of information, the data-collection process faced several challenges. One of the biggest obstacles was the different data-collection methods applied across countries. Different countries employ various approaches to collecting and reporting data on restoration efforts, which results in inconsistencies and makes it difficult to create a comprehensive and consistent overview of the region's restoration progress. For instance, some countries lack data specifically focused on the Mediterranean region, while others may have used different definitions of "forest" or "restoration", which further complicates efforts to standardize information. These varying definitions, along with discrepancies between national reports and literature estimates, created a significant barrier to obtaining accurate data.

Status of the Agadir Commitment 5 years after its adoption

The assessment suggests that in 2017–2022, **between 1.3 and 2.3 million ha** were restored in the Mediterranean region by the **nine countries**[8] that endorsed the Agadir Commitment (Figure 4.4). This estimate was derived as follows:

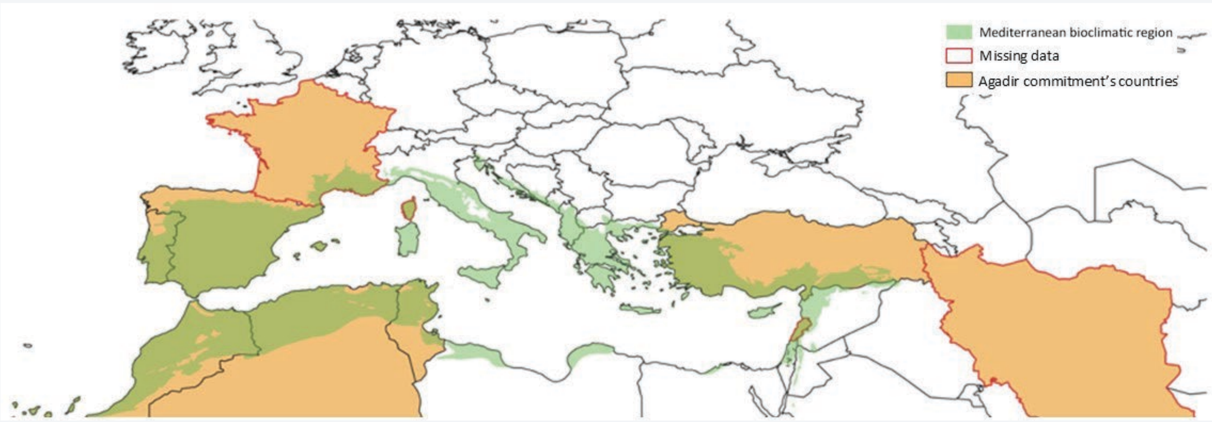
Results of data collection:

Silva Mediterranea national focal points provided data for six countries, namely Algeria, Morocco, Portugal, Spain, Tunisia and Türkiye. The total area under restoration was estimated to be **850 000 ha**. This represented 29 percent of the total area being restored in the six countries reported by Roe *et al.* (2021).

- **Estimation of missing data**: For three countries, France, the Islamic Republic of Iran and Lebanon, the area designated for restoration was estimated

[8] The analysis included Algeria, France, the Islamic Republic of Iran, Lebanon, Morocco, Portugal, Spain, Tunisia and Türkiye. Although the Mediterranean bioclimate, according to the available classifications (Dinerstein *et al.*, 2017; Olson *et al.*, 2001; Quézel and Médail, 2003), does not include the Islamic Republic of Iran, the country is a member of *Silva Mediterranea*, whose membership is also open to countries with forest, agricultural or grazing economies that are intimately connected to the Mediterranean region.

Figure 4.4. Mediterranean countries included in the assessment of the Agadir Commitment



Note: The Mediterranean bioclimatic limit is the limit of the Mediterranean region in terms of vegetation and climate. Note: Refer to the disclaimer on page ii for the names and boundaries used in this map.

Sources: Quézel. 1985. Definition of the Mediterranean region and the origin of its flora. In: C. Gómez-Campo, ed. *Plant conservation in the Mediterranean area*. Geobotany 7. Dordrecht, Kingdom of the Netherlands, Springer.

United Nations Geospatial. 2020. Map geodata [shapefiles]. New York, USA, United Nations.

to be approximately **418 000 ha** by applying the same ratio of 29 percent to the areas reported in Roe *et al.* (2021), which totalled **1.5 million ha**.

- **Country-level restoration data**: By adding those two estimates, 850 000 ha and 418 000 ha, the total area under restoration is estimated to be approximately **1.3 million ha** in the nine countries. The larger estimate of **2.3 million ha** is obtained by adding the areas for the six countries as reported by the national focal points, 850 000 ha, to the area reported in the database by Roe *et al.* (2021) for the three countries that had missing data (1.5 million ha). Only considering the areas in the database by Roe *et al.* (2021), the estimated area undergoing restoration in the nine countries in 2017–2022 is 4.4 million ha. This accounts for 71 percent of the restoration activities conducted across the 24 Mediterranean countries, totalling 6.2 million ha, as reported in the same database.

Addressing data gaps and improving monitoring frameworks

These figures are promising and indicate progress towards meeting the Agadir Commitment through the participating countries'substantial restoration efforts. Collectively, these nations account for up to 71 percent of the total restoration activity across the 24 Mediterranean countries, demonstrating their dedication and strong efforts towards meeting the goals of the commitment. However, beyond this key finding, a major takeaway from this assessment is the urgent need for a unified definition of "restoration", and for improved and systematic monitoring and data-collection systems in the Mediterranean region. A more standardized, unified approach to monitoring restoration efforts across countries would greatly improve the quality and reliability of the data. Such an improved monitoring system is key to identifying priority areas for restoration, enabling more effective planning and resource allocation. The integration of advanced monitoring technologies, such as satellite imaging and remote sensing, could play a crucial role in improving data collection, offering robust, detailed and easily accessible information about restoration progress. Furthermore, the existing strong regional cooperation among Mediterranean countries and stakeholders is essential for sharing methodologies, data and best practices, which will collectively enhance the overall restoration efforts in the region.

The UN Decade offers a valuable opportunity to improve restoration monitoring in the Mediterranean region. By fostering regional cooperation and using cutting-edge technologies, the region can better assess its progress and attract global attention and investment. Addressing data gaps and improving monitoring frameworks is key to realizing the full potential of the Agadir Commitment and achieving the broader global goals.

Standards-based restoration of Mediterranean forests

The role and challenges of ecological restoration in the Mediterranean region

The onset of the UN Decade and global concerns about the state of nature have led to increased commitments, interest and investment in worldwide restoration efforts. Ecological restoration (Box 4.4) is a key tool for addressing global environmental crises, including climate change, biodiversity loss and land degradation, as well as for achieving the global Sustainable Development Goals and other related multilateral environmental agreements (Anderson *et al.*, 2019; IPBES, 2019; Strassburg *et al.*, 2020). Ecological restoration contributes to re-establishing the balance between nature and culture, revitalizing nature, and fostering sustainable and healthy growth and development.

In the Mediterranean basin, natural processes coupled with human activities have led to species losses and altered ecosystem functions, diminishing the supply of ecosystem services (Peñuelas *et al.*, 2017). Societies in the Mediterranean basin have been fighting against land degradation for centuries. Practices aimed at

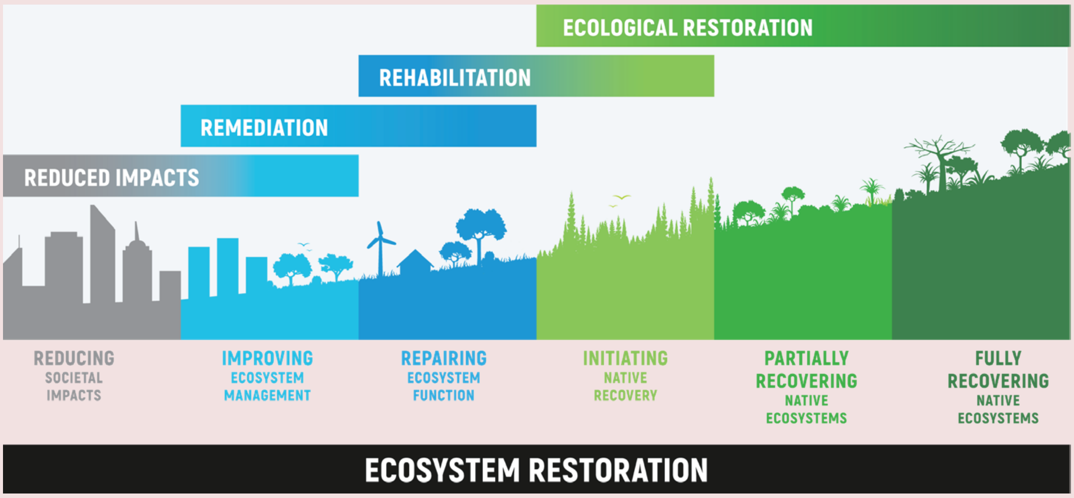
Box 4.4.

The restorative continuum

As stated by the United Nations Environment Programme (UNEP), p. 7, and as shown in the figure, ecosystem restoration is:

> *the process of halting and reversing degradation, resulting in improved ecosystem services and recovered biodiversity. Ecosystem restoration encompasses a wide continuum of practices, ranging from management activities that reduce societal impacts to full ecological restoration."*[i]

Within this continuum, ecological restoration represents the most comprehensive approach, positioned at the far right end. Defined as "the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed,"[ii] ecological restoration aims to fully restore native ecosystems. Unlike other restoration activities, it seeks to return ecosystems or landscapes to their natural state as if degradation had not occurred, while accounting for environmental changes such as rising temperatures and shifting precipitation patterns due to climate change. Ecological restoration prioritizes biodiversity recovery and ecosystem integrity, ensuring the sustained delivery of ecosystem services and contributing to human well-being.



Note: The restorative continuum encompasses a variety of activities and interventions aimed at improving environmental conditions and reversing ecosystem degradation and landscape fragmentation. It emphasizes the interconnections among these different actions and acknowledges that the specific characteristics of each locality determine the most appropriate interventions for different parts of the landscape. Progressing along the continuum from left to right, both ecological health and biodiversity outcomes, as well as the quality and quantity of ecosystem services, tend to improve. It is important to note that ecological restoration can take place not only in natural areas but also within urban, agricultural and industrial landscapes.

Sources: [i] UNEP. 2021. Becoming #GenerationRestoration: Ecosystem Restoration for People, Nature and Climate. Nairobi. https://openknowledge.fao.org/server/api/core/bitstreams/4e57915f-a5a3-4867-a771-57cceb36230b/content

[ii] Gann, G.D., McDonald, T., Walder, B., Aronson, J., Nelson, C.R., Jonson, J., Hallett, J.G. *et al.* 2019. International principles and standards for the practice of ecological restoration. Second edition. *Restoration Ecology*, 27(S1): S1–S46. https://doi.org/10.1111/rec.13035

regulating the hydrological cycle and protecting soils, along with multiple techniques to promote vegetation recovery, demonstrate the richness of traditional knowledge in this field.[9]

Efforts to combat land degradation have evolved into comprehensive restoration initiatives as awareness of the diverse services provided by forests has increased. However, this transition faces several challenges. Management inertia often overlooks the spatial and temporal variability of soils and climate (Navarro-González *et al.*, 2013; Ramón Vallejo *et al.*, 2012). Prioritizing specific objectives, such as establishing tree cover or sequestering carbon, frequently neglects other essential forest ecosystem services (Derak and Cortina, 2014; Temperton *et al.*, 2019). Additionally, the growing number of actors involved in ecological restoration projects, many of whom lack training in ecological restoration objectives and techniques, along with gaps in knowledge exchange, have hindered this transition (Mañas-Navarro *et al.*, 2023; Nelson *et al.*, 2017). Last, the lack of political commitment and adequate funding has limited the ambition of restoration projects (Cortina-Segarra *et al.*, 2021; Varela *et al.*, 2020).

Analysis of forest restoration projects reveals several shortcomings, including the oversimplification of "ecological restoration" to just reforestation and the inadequate prioritization of areas that are most in need of restoration (Cuenca, Melero and Cortina, 2016; Nunes *et al.*, 2016). Other issues include the use of a limited variety of species, the failure to identify reference ecosystems, and the lack of ongoing management, monitoring and evaluation efforts. As illustrated in the previous section on assessing restoration, poor data management, and reporting and dissemination of results further limit the impact of these projects (Cuenca, Melero and Cortina, 2016). The absence of social participation in restoration projects often leads to public disengagement and social conflicts (Derak *et al.*, 2018; Vila Subirós *et al.*, 2016). In this context, procedures and tools are essential to ensure that restoration projects adhere to globally and locally recognized principles and standards of practice.

Best practices, standards and certification systems

Best practices, standards of practice and certification systems are necessary tools for implementing ecological restoration in a manner that reduces ecological, social and financial risk, while enhancing outcomes and return on investment for both people and nature (also see the discussion on knowledge sharing in the section on the role of the Mediterranean region in the UN Decade). A best practice is a method or technique that has been generally accepted as producing effective results consistent with intended objectives. Standards of practice are documented agreements or frameworks that outline consistent and accountable criteria, guidance and definitions for the effective delivery or application of a service or process. Standards are thus founded on best practices, and they should be designed to recognize that best practices evolve over time. A certification system is the provision by an independent body or third party of written assurance (a certificate) that the product, service or system in question meets specific requirements (standards).

Standards and certification systems are common in many sectors, including public health, environmental management and forest management. In the field of ecological restoration, standards serve multiple vital functions: they provide guidelines for designing effective restoration projects, establish benchmarks for training, and create frameworks for continuing education. Moreover, standards play a significant role in raising social awareness about the numerous benefits of ecological restoration. They enhance professional credibility and recognition, offer legal and ethical guidance, and facilitate the reporting and assessment of restoration project outcomes (Blind *et al.*, 2023; ISO, 2014). Consequently, standards are crucial for practitioners, policymakers, decision makers and financing agencies.

International organizations have developed standards for the practice of ecological and ecosystem restoration. One notable example is the Society for Ecological Restoration (SER), which has published the second edition of its International Principles and Standards for the

[9] See for example https://wocat.net/en/

Practice of Ecological Restoration (Gann *et al.*, 2019). The FAO-led Taskforce on Capacity Building for the UN Decade has published Ecosystem Restoration Standards of Practice (Nelson *et al.*, 2024). Principles and guidance have also been published for rewilding, nature-based solutions, and other adjacent and relevant topics. International bodies, such as the Convention on Biological Diversity (CBD), FAO, International Union for Conservation of Nature (IUCN), the United Nations Framework Convention on Climate Change (UNFCC), the United Nations Convention to Combat Desertification (UNCCD) and UNEP, along with funding agencies like the World Bank, Global Environmental Facility, Inter-American Development Bank, Asian Development Bank and African Development Bank, are increasingly recognizing the value of standards in ecosystem and ecological restoration. For example, the guide to implementing Target 2 (the restoration target) of the Kunming-Montreal Global Biodiversity Framework (GBF) defines "effective restoration" as standards-based restoration underpinned by agreed principles resulting in balanced net gain for people and nature (FAO, SCBD and SER, 2024). As interest in standards-based restoration grows, the accessibility of these standards is increasing. For example, the SER standards have been translated into French, Chinese, Korean, Portuguese, Spanish and Ukrainian, with several other languages to be released soon. SER has also developed standards for the restoration of mining sites (Young *et al.*, 2022), standards for seed management (Pedrini and Dixon, 2020) and, together with WWF Spain, standards for the certification of Mediterranean forest restoration projects (Colomina *et al.*, 2023).

Standards for the certification of Mediterranean forest restoration projects

In 2011, a multidisciplinary panel of experts convened by WWF Spain produced the first version of the standards for the certification of Mediterranean forest restoration (Colomina *et al.*, 2023). These standards were aimed at guiding the restoration of Spanish forests, considering their ecological, cultural, social, economic and

Table 4.2. Typologies of forest restoration actions in Spain, in addition to reforestation of areas previously assigned to other land cover types

Typology	Description
Restoration to **prevent wildfires** and the impacts of climate change	Wildfire prevention and climate change adaptation, including strategic silvicultural treatments and fuel management to reduce the risk of increased fire severity and frequency, decrease vulnerability to drought, and increase ecosystem resilience.
Restoring **burnt** forests	Post-fire restoration through the introduction of species that confer resilience and promote biodiversity, establishment of dispersal nuclei, management of regeneration, and management of fuel and burnt wood.
Restoring forests to combat **desertification**	Actions to reverse desertification and adapt to climate change.
Restoring **iconic forest species** and **unique forests**	Emblematic forest species and unique forests.
Restoring forest planted under the **General Reforestation Plan and the Common Agriculture Policy**	Management and rewilding of forests created under the General Reforestation Plan (1939–1986) and EU Common Agriculture Policy (1994).

Note: The term "forest" is used as a free translation of the Spanish *monte*, rural areas not covered by farmland, water bodies or infrastructure. This includes areas covered by trees, shrubs and grasses.

Source: Cortina-Segarra, J., Disante, K., Pérez, S. & Oliet, J. 2022. *Identificación de zonas forestales a restaurar en España según criterio experto*. Internal report (unpublished). WWF Spain.

Figure 4.5. Steps towards the production of version 4.0 of the WWF/SER Standards for the Certification of Mediterranean Forest Restoration Projects

Source: Adapted from Colomina, D., Cortina, J., Melero, M., Gann, G. & *et al*. 2023. *WWF-SER standards for the certification of ecological projects for forests in Spain.* Version 4.0. SER & WWF Spain. https://ser-europe.org/files/2024/06/WWF-SER-Standards-Certification-Forest-Restoration-FINAL.pdf

Figure 4.6. Principles and criteria included in the WWF/SER Standards for the certification of Mediterranean forest restoration projects developed in Spain

1 Planning and design

1.1 Context analysis
1.2 Baseline inventory snd assessment
1.3 Assurance and land availability
1.4 Commitment to compliance with standards
1.5 Stakeholder participation
1.6 Reference ecosystem
1.7 Design and logistics of proposals for action
1.8 Ecological protection of the site
1.9 Aftercare and ongoing management
1.10 Monitoring and evaluation
1.11 Information management
1.12 Reports

2 Implementation

2.1 Ecological protection of the site
2.2 Hiring suitable personnel
2.3 Specifications of machinery and materials
2.4 Compliance with planning and design
2.5 Compliance with environmental, labour and health and safety regulations
2.6 Communication with key stakeholders
2.7 Documentation

3 Monitoring, evaluation, aftercare and ongoing management

3.1 Monitoring in an adaptive management framework
3.2 Aftercare and ongoing management

Source: Colomina, D., Cortina, J., Melero, M., Gann, G. & *et al*. 2023. *WWF-SER standards for the certification of ecological projects for forests in Spain.* Version 4.0. SER & WWF Spain. https://ser-europe.org/files/2024/06/WWF-SER-Standards-Certification-Forest-Restoration-FINAL.pdf

governance contexts (Table 4.2).[10] Following the publication of SER's International Principles and Standards for the Practice of Ecological Restoration (Gann *et al*., 2019), WWF Spain and SER joined efforts to develop a new version of them, which would be aligned with international standards and validated through various pilot projects (Figure 4.5). The task was relatively straightforward, as the degree of similarity between the two documents, though generated through separate processes, was very high. Version 4.0 of the WWF/SER standards was thus published in 2023 (Colomina *et al*., 2023).

The final document includes three general principles: (i) planning and design; (ii) implementation; and (iii) monitoring, evaluation, aftercare and ongoing management (Figure 4.6). These principles are further broken down into 21 criteria and 63 indicators, covering all phases of restoration projects.

In addition, the document contains several annexes with supporting (non-binding) materials, including a detailed list of recommended verifiers for evaluating the established indicators,

[10] Here, we use the term "forest" as a free translation of the Spanish "*monte*", rural areas not covered by farmland, water bodies or infrastructure. This includes areas covered by trees, shrubs and grasses. Similarly, the WWF/SER standards should be applicable to all Spanish forests, including those that are not currently under a Mediterranean climate.

guidelines for reporting on forest ecosystem restoration projects, and a summary of the reference legislation on which the document is based. A list of acronyms and abbreviations and a glossary have been included to facilitate the use of the standard.

Towards forest restoration standards for the Mediterranean basin

The WWF/SER standards are a highly useful tool for raising awareness among practitioners and the public about the concept and purpose of ecological restoration. They also guide practitioners through the different phases of a restoration project and define a framework for the evaluation of projects by consultants, public administrations and funding entities. In addition to reflecting best practices, the standards enhance the transparency, detail and rigour of the evaluation process for restoration projects.

Improving the quality of restoration projects by following standards entails a greater investment of time and money in the design phase and subsequent phases. But the most important limiting factor for the application of the WWF/SER standards may be the difficulty in ensuring the ongoing management of the project in the medium and long term. This limitation is due to a governance and financing system that avoids medium- and long-term commitments. Thus, changes in the way society perceives, plans and carries out restoration are needed for the desired outcomes to be realized. Incorporating timelines that are meaningful both socially and ecologically could also help reduce the administrative burden associated with restoration projects.

The value of the standards for the certification of Mediterranean forest restoration projects is also their potential use as a model for developing valid standards in other countries of the Mediterranean basin and other regions with a Mediterranean climate. The standards are tailored to a specific socioecological context, which is reflected, for example, in the selection of experts who draft them and the stakeholders involved in the consultation process. Therefore, their direct application outside the scope for which they were created is not advisable. However, they could be readily adapted to other socioecological contexts within the Mediterranean region.

Finally, standards can also be used as a basis for complementing existing certification systems and designing new ones. For instance, many criteria outlined in the WWF/SER standards are integrated into forest management certification systems like the Forest Stewardship Council (FSC),[11] allowing for their complementary application (Box 4.5).

Box 4.5.

Developing a certification system

Developing a certification system can be a lengthy process, and many different approaches have been used. Typically, the procedure includes the following steps: (i) a thorough discussion about the value of certification; (ii) exploring different certification models; (iii) establishing an appropriate governance structure, which includes determining certificate ownership and management of technical systems; (iv) coordinating the financing framework; (v) outlining the audit process, including auditor profiles and training programmes; and (vi) creating procedures for resolving disagreements among stakeholders. Additionally, certification systems often follow a participatory approach.

Recommendations to elevate the quality of forest restoration projects

Ecological and ecosystem restoration standards should help improve the quality of delivery and the associated outcomes of restoration projects, for both people and nature. Measures to implement standards-based restoration in Mediterranean forests under the UN Decade, the Agadir Commitment and the European Nature

11 https://fsc.org/en

Restoration Law include:

- International organizations, including the European Union, should recommend that **states adopt existing recognized standards of practice** to elevate the quality of projects, improve restoration outcomes for people and nature, assist in developing comprehensive evaluations of restoration projects, and facilitate reporting and accountability, especially for global environmental obligations, such as Target 2 of the GBF.
- Mediterranean states should **integrate standards in national restoration plans** and develop more specific sectoral standards when needed, taking into account the particular requirements and socioecological contexts of these sectors.
- Standards should be **disseminated by public administrations** to raise social awareness about the benefits of ecological restoration, increase the transparency of national restoration plans, restoration programmes and projects, and engage citizens in ecological restoration and European nature policies.
- **Funding entities should apply standards** and, when available, certification systems, as additional assets for ranking ecological restoration projects and actors and reducing risk and uncertainty for their investments while increasing the likelihood of achieving intended outcomes.
- Standards should be **elevated as the expected norm for both private and publicly implemented restoration at all scales** (including smallholders and private lands) in order to achieve the ambitious objectives of international agreements, and maximize the overall net ecological and social gains from these restoration efforts.
- **Private sector and investors** have a key opportunity to enhance the credibility and impact of their environmental, social and governance, climate, and biodiversity-related investments by applying high-quality restoration standards. Integrating recognized ecological restoration standards into green investment strategies will not only strengthen the environmental integrity of private sector contributions but also increase transparency, attract responsible capital, and demonstrate measurable contributions to international climate and biodiversity goals.

Financing restoration in the Mediterranean region

Funding forest and landscape restoration in the Mediterranean region

Identifying current and prospective funding sources for FLR at the level of the Mediterranean region is a complex and challenging task. The funding landscape is fragmented, with resources scattered across various multilateral and bilateral sources. These funds are often embedded within broader environmental, climate, drought and desertification, and more general sustainability-related development programmes, making it difficult to directly link them to FLR-specific goals.

This challenge is especially critical given the Mediterranean region's unique vulnerabilities to environmental degradation and climate change, making the need for robust and sustained FLR initiatives more urgent than ever. These efforts can help mitigate climate risks, restore land and ecological balance, halt desertification and combat drought, as well as enhance the region's resilience to future shocks.

To navigate this complex funding framework, conducting a thorough analysis and monitoring of available financial instruments is essential. This includes mapping existing multilateral mechanisms offered by international and supranational organizations, development banks, and environmental and climate finance bodies (Box 4.6). Additionally, bilateral agreements often cover forests and restoration efforts, and these must also be carefully examined and aligned with the objectives of FLR.

This section focuses primarily on **international and supranational funding sources** for FLR, as they represent a significant portion of the financial flows that are relatively well documented

Box 4.6.

A short summary of multilateral agreements related to forest and landscape restoration

Many Mediterranean countries have included restoration and reforestation in their commitments to reduce carbon emissions and enhance climate resilience. Forest and landscape restoration can be pivotal in achieving these nationally determined contribution (NDC) targets, particularly in carbon sequestration and ecosystem resilience. Aligning FLR projects with national climate strategies not only strengthens their potential for securing funding but also ensures that restoration efforts contribute to global climate action.

Forest and landscape restoration is also strongly linked to the Kunming-Montreal Global Biodiversity Framework (GBF), which emphasizes the restoration of ecosystems as a key strategy for halting biodiversity loss. The GBF, adopted under the Convention on Biological Diversity (CBD), sets ambitious targets for ecosystem restoration, aiming to restore at least 30 percent of degraded ecosystems globally by 2030. In this context, FLR in the Mediterranean contributes directly to the goals of the GBF by promoting biodiversity conservation, habitat restoration, and the sustainable use of landscapes. Aligning FLR initiatives with both the GBF and national biodiversity strategies enhances their potential to secure international funding and support, while also advancing global conservation goals.

Beyond climate and biodiversity objectives, the Bonn Challenge, launched in 2011, is a global effort to restore 350 million hectares of degraded and deforested land by 2030, with many Mediterranean countries pledging significant restoration efforts under this initiative. The Mediterranean region is vulnerable to desertification and land degradation and is a critical area where FLR can significantly contribute to the Bonn Challenge targets. Moreover, the United Nations Convention to Combat Desertification (UNCCD), which addresses land degradation and desertification, recognizes FLR as a key strategy for improving land productivity and resilience in arid regions like the Mediterranean. By aligning FLR efforts with the goals of the UNCCD, restoration projects can attract additional funding from initiatives focused on combating land degradation and desertification.

Last but not least, the United Nations Decade on Ecosystem Restoration 2021–2030 further amplifies the global focus on FLR, calling for the restoration of ecosystems worldwide to combat climate change, biodiversity loss and food insecurity. It provides a powerful platform for FLR efforts in the Mediterranean to secure support, funding and international recognition by aligning with the global momentum for ecosystem restoration.

and coordinated across countries. International mechanisms are critical for enabling large-scale and cross-border restoration initiatives in the Mediterranean region, often serving to complement and catalyse national efforts.

It is important to note, however, that **domestic funding for restoration activities is steadily increasing** across Mediterranean countries. Governments are progressively allocating national budgets and developing targeted programmes for ecological restoration, sustainable land management and climate adaptation. Nevertheless, monitoring domestic funding remains challenging due to the lack of systematic tracking, fragmentation across sectors, such as agriculture, water management and forestry, and variability in how restoration activities are categorized within national expenditure frameworks.

Strengthening transparency and reporting on domestic FLR funding is therefore essential to obtain a comprehensive understanding of the total investment landscape and to leverage the full potential of synergies between domestic and international resources.

Moreover:

- Policies and funding are inextricably linked; a well-aligned policy and funding ecosystem is crucial for the success of FLR efforts. The allocation of financial resources for FLR often depends on national and regional policies that prioritize ecosystem conservation and restoration as well as climate resilience. Strong policy frameworks not only attract funding but also guide its effective deployment by setting clear restoration targets, implementation road maps and compliance mechanisms. In turn, funding availability can support policy development as financial incentives can drive the adoption of more ambitious environmental agendas.
- Forest and landscape restoration is strongly linked to global restoration frameworks such as the GBF, the Climate Convention, the Bonn Challenge, the UNCCD and the UN Decade.
- The challenge lies not only in identifying these sources but also in recomposing them into a coherent framework that highlights synergies and opportunities. The multiplicity of funding angles, ranging from biodiversity conservation and carbon sequestration to rural development and climate resilience, offers a diverse array of funding perspectives. However, this diversity requires a strategic approach to harmonize these funds and ensure they can be effectively directed towards comprehensive FLR efforts in the Mediterranean region.
- Furthermore, projects and processes in FLR are intertwined. Projects serve as the vehicles for implementing broader restoration processes, while processes, in turn, define the strategic direction and continuity of projects. Effective FLR depends on ensuring that individual projects contribute to the long-term objectives of restoration, resilience and sustainability. Aligning projects within ongoing processes helps ensure that restoration efforts are not isolated actions but part of a cohesive strategy, fostering continuity and scaling impact. Understanding this symbiotic relationship is essential for managing both funding and restoration efforts effectively.

In summary, the process of consolidating a clear picture of funding for FLR in the Mediterranean region necessitates an in-depth examination of diverse funding streams and perspectives. By identifying and aligning these sources within a coherent framework, stakeholders can better deploy their contributions – technical, in-kind and financial – maximizing the available opportunities, creating a sustainable financing model for FLR, and ensuring the convergence of efforts around shared priorities.

Exploring the main active international and supranational funding sources and opportunities for the Mediterranean region

Quantifying investments in the region presents challenges, and this section offers a representative rather than an exhaustive overview of international and supranational funding sources. An overview of the key financial instruments and funding opportunities available for FLR projects in the Mediterranean is presented, highlighting their objectives, scope and impact. These funding sources range from multilateral climate funds and EU programmes to development agencies, private foundations and non-profit initiatives.

Funds associated with multilateral agreements

- **Green Climate Fund (GCF).** The GCF is the world's largest climate-focused financial institution, established under the UNFCCC, to support developing countries in mitigating and adapting to climate change. It provides grants, concessional loans, equity and guarantees to finance projects in key sectors such as forestry, landscape restoration, renewable energy and climate-resilient agriculture. The GCF mobilizes public and private investments to drive low-emission, climate-resilient development, prioritizing initiatives that align with national climate strategies (NDCs) and contribute to global climate goals, including the Paris Agreement. The GCF has approved funding for the sustainable management of Argan forests in Morocco (2017–2028, USD 39,3 million grant) and in February 2025, its first single-country investment in Serbia (2025–2032, USD 25 million grant) to enhance forest resilience. It can fund FLR projects in regions that include Mediterranean countries.

- **Global Environmental Facility (GEF).** The **GEF** is an international financial institution that funds projects to address global environmental challenges, including biodiversity conservation, climate change mitigation and adaptation, land degradation, and sustainable forest management. The GEF is channelling investments in the Mediterranean region through integrated projects incorporating FLR, ecosystem restoration, and sustainable forest management components (Box 4.7). Many GEF initiatives embed sustainable land management practices – such as reforestation, agroforestry and improved forest management – as key elements within broader ecosystem restoration programmes. This integrated approach helps enhance carbon sequestration, improve water regulation and safeguard biodiversity while simultaneously boosting local livelihoods. In addition, the GEF's investment strategy in the Mediterranean region leverages catalytic funding mechanisms that blend grant support with co-financing from local governments and international donors. This multistakeholder approach not only scales up pilot projects in sustainable forest management and ecosystem restoration but also creates platforms for sharing innovative practices and building regional capacity. By integrating FLR within larger ecosystem-based adaptation and mitigation frameworks, the GEF is helping transform degraded areas into multifunctional landscapes supporting both environmental sustainability and socioeconomic development across the Mediterranean.
- **Land Degradation Neutrality Fund (Mirova/UNCCD).** The LDN Fund is a public–private investment fund supporting land restoration and sustainable forestry. Despite it being a source of funding for the Mediterranean, according to Mirova's 2023 LDN Fund impact report (Mirova, 2023), only one project on agricultural practices has been funded in the region.
- **World Bank and PROGREEN Fund.** The **World Bank** supports various environmental initiatives, including FLR, through funding and technical assistance. In the Mediterranean region, countries like **Lebanon** and **Türkiye** have benefited from reforestation projects aimed at restoring native forests and combating land degradation. The **PROGREEN Fund** is a multidonor trust fund managed by the World Bank, dedicated to promoting sustainable land use and enhancing forest management. It has funded activities related to the sustainable management of forest ecosystems, including restoration, in Algeria, Egypt, Lebanon and Morocco.

Box 4.7.

Investments in the Mediterranean region under the sixth, seventh and eighth replenishments of the Global Environment Facility

Over the course of its sixth (2014–2018) and seventh (2018–2022) replenishments, the Global Environment Facility (GEF) allocated a total of USD 791.74 million to fund 123 approved projects selected among 170 project submissions, involving at least one Mediterranean country (Table A, Figure B). For its eighth replenishment (2022–2026), the GEF has already allocated USD 522.25 million in funding as of April 2025. The GEF's funding under the latest replenishment is expected to increase, underscoring its ongoing commitment to tackling global environmental challenges (Table A). The GEF has played a key role in driving impactful change in the Mediterranean region by supporting diverse projects that foster environmental sustainability, funding a total of 156 projects in the focal areas of biodiversity, climate change and land degradation (Table C). This funding has not only focused on addressing environmental concerns at the national level but has also emphasized cross-border collaboration to tackle shared challenges, such as climate change, biodiversity loss and ecosystem degradation.

Table A. Summary of projects in the Mediterranean region funded by the GEF during its sixth, seventh and eighth replenishments, 2014–2025

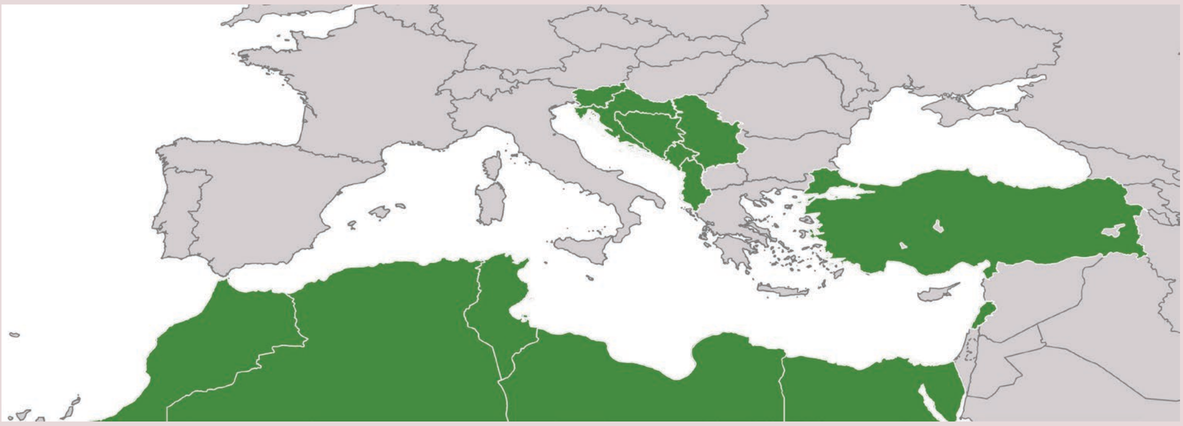
	GEF 6 2014–2018	GEF 7 2018–2022	GEF 8 2022–2026 (as of April 2025)	Total (as of April 2025)
Total investment in the Mediterranean region (USD)	306 418 769	485 316 960	522 249 661	1 313 985 390
Number of single-country projects	64	41	33	138
Number of multicountry projects	32	33	28	93
Number of projects submitted	96	74	61	231
Number of projects approved	54	69	27	150

Note: Multicountry projects include at least one Mediterranean country but do not focus solely on the Mediterranean region.

Source: GEF. 2025. Project Database [Accessed on 27 May 2025]. https://www.thegef.org/projects-operations/database

The GEF has fostered regional cooperation among Mediterranean countries while also facilitating broader global collaboration across multiple continents. Mediterranean nations have partnered with countries around the world through multicountry projects. As a result, GEF funding has supported initiatives in 16 countries throughout the Mediterranean region, strengthening international environmental efforts and fostering cross-border partnerships (Figure B).

Figure B. Mediterranean countries implementing projects under the sixth, seventh and eighth replenishment cycles of the Global Environment Facility



Note: Refer to the disclaimer on page ii for the names and boundaries used in this map.
Source: United Nations Geospatial. 2020. Map geodata [shapefiles]. New York, USA, United Nations.

Table C. Number of projects per focal area in the Mediterranean region under the sixth, seventh and eighth replenishment cycles of the Global Environment Facility, as of April 2025

Focal area	GEF 6	GEF 7	GEF 8
Biodiversity	13	13	6
Land degradation	10	5	3
Climate change	38	21	17
Biodiversity, land degradation	1	4	–
Biodiversity, climate change, land degradation	3	4	11
Climate change, land degradation	2	1	1
Biodiversity, climate change	2	1	–
Total	**69**	**49**	**38**

Source: GEF. 2025. Project Database [Accessed on 27 May 2025]. https://www.thegef.org/projects-operations/database

- The European Union's thematic and geographically related funding and programmes.
  The European Union provides a range of funding opportunities to support FLR in the Mediterranean region, aligning with its commitments to biodiversity conservation, climate resilience and sustainable land management. The most relevant EU funding instruments for FLR are:
  - **NDICI – Global Europe.** This instrument covers EU cooperation with all third countries, except for pre-accession beneficiaries and overseas countries and territories from the geographic programmes (Directorate-General for International Partnerships [DG INTPA], Directorate-General for the Middle East, North Africa and the Gulf [DG MENA],[12] Directorate-General for Enlargement and the Eastern Neighbourhood [DG ENEST]).
  - **Horizon Europe (Directorate-General for Research and Innovation [DG RTD]).** This is the European Union's research and innovation programme for 2021–2027:
    - **PRIMA Foundation**, as described in Box 4.8.
    - **Cluster 6: Food, Bioeconomy, Natural Resources, Agriculture & Environment.** This funding stream of the programme funds research and innovation projects aiming to reduce environmental degradation, halt biodiversity decline and better manage natural resources through transformative changes in urban and rural areas. This includes support for sustainable forestry, afforestation and reforestation efforts. Calls for proposals often target Mediterranean and African regions. An EU Mission under Horizon Europe supports related research:
      - **A Soil Deal for Europe** aims to establish 100 living labs and lighthouses to lead the transition towards healthy soils, promoting sustainable land management practices.
      - **Adaptation to Climate Change** supports regions and communities in becoming climate resilient, including initiatives for afforestation and reforestation to enhance ecosystem resilience.
  - **LIFE Programme (Directorate-General for Environment [DG ENV]):**
    - **LIFE Nature & Biodiversity.** This LIFE subprogramme funds forest conservation, reforestation and ecosystem restoration projects.
    - **LIFE Climate Change Mitigation and Adaptation.** This one supports adaptation to climate change, including wildfire prevention and water-efficient forestry.
  - **Innovation Fund (Directorate-General for Climate Action [DG CLIMA]).** This fund supports carbon sequestration projects, including afforestation and nature-based solutions for carbon storage.
  - **European Regional Development Fund (ERDF) (Directorate-General for Regional and Urban Policy [DG REGIO]).** The main Interreg programmes of relevance, funded by DG REGIO, are described in Box 4.9.
    - **ENI CBC Mediterranean Sea Basin Programme.** This programme has been replaced by **Interreg NEXT MED**, which continues to support cross-border cooperation initiatives across the Mediterranean, offering new opportunities to promote sustainable

[12] On 1 February 2025, the European Commission established the Directorate-General for the Middle East, North Africa and the Gulf (DG MENA), marking an important step in strengthening the European Union's engagement with these strategically significant regions. DG MENA acts as the main interface between the European Commission and countries across North Africa, the Middle East and the Gulf, aiming to build resilient, forward-looking partnerships based on mutual interests. DG MENA replaces the regional responsibilities previously held by the Directorate-General for Neighbourhood and Enlargement Negotiations (DG NEAR) for the Mediterranean and extends its geographical scope to the Gulf region. This restructuring reflects the growing importance of tailored external action and a more focused approach to the unique political, economic and environmental challenges faced by these areas. For more information, visit: https://ec.europa.eu/commission/presscorner/detail/en/ip_25_395.

Box 4.8.

PRIMA – Partnership for Research and Innovation in the Mediterranean Area

PRIMA is the most ambitious joint programme to be implemented within the framework of Euro-Mediterranean cooperation. Since 2018, PRIMA has been organizing competitive calls to fund projects that contribute to the sustainable use of natural resources, economic growth and stability in the Mediterranean region. The idea behind PRIMA is to "build research and innovation capacities and develop knowledge and joint innovative solutions for water and agrifood systems in the Mediterranean area."[i] The main objectives are to:

> *make the agrifood systems and integrated water provision and management more climate resilient, efficient, cost-effective and environmentally and socially sustainable; [and] contribute to solving water scarcity, food security, nutrition, health, well-being and migration problems.*[i]

PRIMA also aims to contribute to the United Nations 2030 Agenda for Sustainable Development through the achievement of the Sustainable Development Goals. The programme, which is funded by the Directorate-General for Research and Innovation, brings together EU member states, Horizon 2020 associated countries and Mediterranean partner countries on an equal footing in terms of co-ownership, co-management and co-funding. The European Union participates in this initiative under Article 185 of the Treaty on the Functioning of the European Union (TFEU). To date, 20 EuroMed countries have committed to PRIMA, including Algeria, Bulgaria, Croatia, Cyprus, Egypt, France, Germany, Greece, Israel, Italy, Jordan, Lebanon, Luxembourg, Malta, Morocco, Portugal, Slovenia, Spain, Tunisia and Türkiye, thereby formally becoming PRIMA participating states.

The partnership is funded through a combination of contributions from those PRIMA participating states, which currently amount to EUR 274 million, and EUR 220 million from the European Union via Horizon 2020, its research and innovation funding programme (2014–2020). Additionally, there will be an increase of EUR 105 million from the EU budget under Horizon Europe for the period from 2025 to 2027, which will be matched by the participating states.

Source: [i] European Union. Partnership for Research and Innovation in the Mediterranean Area, 7 August 2017. Decision (EU) 2017/1324 and Decision (EU) 2024/1167. Also available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=legissum:4309195

development, including projects focused on Mediterranean forest restoration, biodiversity conservation, and climate resilience (see Box 4.9).

- **Mediterranean Network of Forest Research and Innovation (MENFRI)**. This initiative funded by the European Union promotes sustainable forest management across Mediterranean countries by fostering cooperation between nations in the northern and southern Mediterranean regions. It focuses on sharing traditional knowledge and innovative techniques to increase forest resilience and create economic opportunities within the forest sector.
- A **New Pact for the Mediterranean** is being developed through broad consultations and is expected to be presented in 2025. It will serve as the European Union's renewed road map for engagement with countries in the region, aiming to deepen political partnerships and foster convergence on key issues. Building on the 2021 Agenda for the

Mediterranean, it will focus on concrete, people-centred initiatives in areas such as clean energy, water resilience, climate preparedness, trade, education, mobility and connectivity.

- **French Development Agency (AFD).** AFD supports FLR in the Mediterranean and North Africa through climate adaptation, biodiversity conservation and sustainable land management projects. AFD provides grants, concessional loans and technical assistance to governments, non-governmental organizations and local stakeholders to implement large-scale restoration initiatives. The agency prioritizes reforestation, combating desertification and sustainable forestry, often integrating FLR into broader climate resilience and rural development programmes. AFD collaborates with EU institutions, the GEF and regional development banks to co-finance projects that enhance ecosystem services and strengthen community livelihoods.
- **International Climate Initiative (IKI).** The IKI is a key funding instrument of the German Federal Government aiming to support climate action and biodiversity conservation in developing and emerging countries. Managed by the Federal Ministry for Economic Affairs and Climate Action (BMWK), IKI finances projects across four main areas: mitigation, adaptation, natural carbon sinks and forests, and biodiversity. In the Mediterranean region, IKI supports FLR as part of broader efforts to enhance climate resilience, protect ecosystems, and promote sustainable land management. IKI funds are delivered through grants to international and local organizations, including non-governmental organizations, research institutions, and German development agencies, such as the KfW Development Bank and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), which often act as implementing partners. In the context of FLR, IKI projects focus on restoring degraded landscapes, integrating nature-based solutions, and strengthening local capacities. The initiative also emphasizes multistakeholder collaboration, gender inclusion, and the mainstreaming of biodiversity into land-use planning. While not exclusively focused on FLR, IKI plays an important role in financing restoration efforts where they intersect with climate and biodiversity goals.
- **International Model Forest Network (IMFN). Canada** contributes to global FLR efforts through its longstanding support of the IMFN, an initiative launched by the Canadian Government in 1992 and supported primarily by Natural Resources Canada. IMFN promotes a participatory, landscape-based approach to sustainable forest management by fostering collaborative platforms across more than 60 model forests worldwide, including in the Mediterranean region. These model forests serve as testing grounds for integrated land-use strategies that align environmental sustainability with socioeconomic development. Canada, through the IMFN Secretariat and targeted funding mechanisms, provides technical support, knowledge exchange and modest seed funding to facilitate multistakeholder governance, innovation in restoration practices, and capacity building. In the Mediterranean region, the Mediterranean Model Forest Network (MMFN) has strengthened cooperation among forested landscapes in Mediterranean countries.
- **European Investment Bank (EIB).** EIB finances green infrastructure, forest restoration and climate resilience projects through low-interest loans, grants and blended finance mechanisms. In the Mediterranean region, EIB supports sustainable forestry, afforestation and wildfire prevention by funding both public sector initiatives and private investments in nature-based solutions. The bank collaborates with EU programmes, international climate funds and development agencies to scale up restoration efforts and promote carbon sequestration, biodiversity protection and sustainable land-use planning. EIB also engages in public–private partnerships to leverage additional funding for FLR and ecosystem restoration initiatives.
- **European Bank for Reconstruction and**

Development (EBRD). The EBRD supports environmental sustainability and climate resilience in its partner countries, including those in the Mediterranean region, through a range of investments and technical assistance. While EBRD does not focus exclusively on FLR, it integrates nature-based solutions, sustainable land management, and climate adaptation components into broader infrastructure, agriculture and rural development projects. EBRD financing – delivered through loans, equity investments and blended finance – often supports reforestation, land rehabilitation and ecosystem services enhancement, particularly where they align with private sector development and green transition goals. The bank collaborates with multilateral climate funds and development partners to mobilize additional resources and build institutional capacity. Its role in supporting FLR is linked to promoting sustainable value chains, carbon sequestration and climate-resilient livelihoods across landscapes.

- **Spanish Agency for International Cooperation (AECID)**. The AECID focuses on fostering international development cooperation, including on environmental protection and Mediterranean forest projects that align with Spain's strategic focus on the Mediterranean region. AECID has been involved in initiatives related to FLR in the region. In 2012, AECID funded a workshop organized by the IUCN's Centre for Mediterranean Cooperation (IUCN-Med) in collaboration with the University of Alicante and the Centre for Environmental Studies in the Mediterranean (CEAM). The workshop focused on forest management and public administration in North African countries, addressing topics such as restoration techniques, combating desertification, and ecosystem services. Additionally, AECID co-leads the "Gendering the Water-Energy-Food-Ecosystems Nexus in the Mediterranean" initiative, which emphasizes the significant role women play in managing water, energy and food resources. This initiative advocates for a gender-transformative approach in policy and governance frameworks, indirectly supporting sustainable land and forest management practices.

Recommendations on financing forest restoration projects

The Mediterranean region has made notable progress in advancing FLR, demonstrating strong leadership and commitment to restoring degraded ecosystems, conserving biodiversity and enhancing resilience to climate change. A wide range of funding sources – including multilateral climate funds, EU programmes, bilateral development agencies, private sector initiatives, and increasing domestic public investments – have supported substantial efforts to bring degraded lands back into productivity and ecological health. National and regional initiatives have led to the development of restoration strategies, the rehabilitation of degraded areas, and growing engagement from local communities and civil society.

Building on these achievements, the Mediterranean region can play an even more prominent role in FLR, serving as a model for other regions facing similar environmental challenges, such as land degradation, biodiversity loss and climate change impacts.

However, despite the availability of financial resources, challenges persist in accessing and effectively utilizing these funds due to complex application processes, fragmented funding landscapes, limited national capacities, and the need for stronger regional coordination. To scale up FLR efforts, improving financial accessibility, enhancing technical support, and fostering cross-border collaboration will be essential. Aligning restoration strategies with international frameworks and global initiatives such as the UN Decade can provide visibility and reinforce commitments to sustainable land management. Additionally, blended finance approaches that combine public funding with private investments can help bridge financial gaps and create long-term sustainability for restoration projects. Strengthening monitoring frameworks and improving data collection on funding flows and restoration outcomes will also be key to ensuring transparency and maximizing impact. By addressing these challenges, the Mediterranean region can establish itself as a global example of successful FLR, securing long-term environmental and socioeconomic benefits.

Overall conclusion

The Mediterranean region has a rich and evolving history in FLR, and has shown notable progress through a landscape approach that integrates ecological, social and economic needs. Restoration efforts have accelerated with the endorsement of key commitments such as the Agadir Commitment and the Antalya Declaration, and through the region's designation as a World Restoration Flagship under the UN Decade.

This chapter highlights the foundations of FLR principles and standards, the region's leadership in restoration initiatives, the role of Mediterranean forests in global restoration agendas, and the growing importance of standards-based restoration. A key focus is placed on the promotion of ecological restoration standards and certification systems to ensure quality and long-term impacts. The assessment of progress towards the Agadir Commitment reveals encouraging results, though it also underlines ongoing challenges in data availability, consistency and monitoring frameworks.

The analysis of financing mechanisms shows a fragmented but expanding funding landscape, with growing contributions from international, bilateral, private and domestic sources. Despite increasing financial opportunities, there remains a need to enhance accessibility, regional coordination, and alignment with global initiatives.

Looking ahead, consolidating these achievements will require strengthened governance, improved monitoring systems, broader application of restoration standards and innovative financing models, including blended finance. With its longstanding commitment, accumulated expertise and regional cooperation structures, the Mediterranean region is well positioned to serve as a global model for successful, high-quality FLR, contributing meaningfully to climate resilience, biodiversity recovery and sustainable development.

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Chapter 5
Fire management in the Mediterranean region

Carolina Gallo Granizo,[1,2] Valentina Bacciu,[3] Jonathan Eden,[2] Elena Hernández Paredes,[4] Celia García Feced,[4] Sahbi Bedhief,[5] Duarte Oom,[1,6] Johann Goldammer,[7] Bastien Dieppois,[2] İsmail Belen,[8] George Mitri,[9] Ümit Turhan,[10] Davide Ascoli,[11] Laurent Alfonso,[12] Jesús San-Miguel-Ayanz[6]

[1] Food and Agriculture Organization of the United Nations, Rome, Italy

[2] Coventry University, United Kingdom of Great Britain and Northern Ireland

[3] Institute for Bioeconomy (IBE), National Research Council (CNR), Sassari, Italy

[4] Ministry for Ecological Transition and Demographic Challenge, Spain

[5] General Directorate of Forestry, Tunisia

[6] Joint Research Centre of the European Commission, Brussels, Belgium

[7] Global Fire Monitoring Center, Fire Ecology Research Group, Max Planck Institute for Chemistry, Mainz, Germany and Freiburg University, Germany

[8] United Nations Forum on Forests, New York, United States of America

[9] University of Balamand, Lebanon

[10] General Directorate of Forestry, Türkiye

[11] University of Turin, Italy

[12] Union for the Mediterranean (UfM), Barcelona, Spain

Introuction

In the Mediterranean, wildfires represent a significant threat to ecosystems and people. In recent decades, Mediterranean ecosystems known for their rich biodiversity are facing rapid degradation due to a combination of human activities and natural factors (Abu Hammad and Tumeizi, 2012; Bajocco *et al.*, 2012; Peñuelas and Sardans, 2021). Human-induced disturbances, such as overgrazing, agriculture and urban expansion, have contributed to this degradation. Additionally, the region faces natural disturbances, such as pest outbreaks and droughts (Paine and Lieutier, 2016; Mathbout *et al.*, 2021). Among these threats, wildfires have emerged as a particularly destructive force, burning hundreds of thousands of hectares of vegetated areas each year and disrupting vital ecosystem services. These fires are especially damaging in transitional zones between wildland areas and human-dominated landscapes, such as the wildland–urban interface (San-Miguel-Ayanz *et al.*, 2024).

Changing climate patterns in the Mediterranean further exacerbate the risk of wildfires, with milder winters, hotter and drier summers, and more frequent and intense extreme weather events (Mariotti *et al.*, 2015; Pastor and Khodayar, 2023; Tejedor *et al.*, 2024). These conditions have led to an extended fire season and more intense wildfires (Rodrigues *et al.*, 2023), posing significant challenges to the preservation of key ecosystem services, such as carbon storage, water cycling, soil protection and biodiversity, as well as the safety of local populations.

Despite the long history of wildfires in Mediterranean ecosystems, recent years have seen a shift in fire regimes (Galizia *et al.*, 2023; Moreira *et al.*, 2023; Badeau *et al.*, 2024). These changes include alterations in intensity, frequency, spatial patterns and types of fire, leading to devastating consequences for both the environment and local communities. For example, in 2021 and 2022, unprecedented wildfires erupted across the region, resulting in extensive damage to forests, agricultural land and infrastructure (Haddad and Hussein, 2021; Giannaros *et al.*, 2022; San-Miguel-Ayanz *et al.*, 2022; Atmiş, Tolunay and Erdönmez, 2023).

Addressing the wildfire crisis requires a multifaceted approach that includes prevention, mitigation and post-fire restoration strategies (Bacciu, Sirca and Spano, 2022; Ascoli *et al.*, 2023; Pulido *et al.*, 2023). International and regional collaboration is crucial for managing wildfire events, as evidenced by initiatives such as the Antalya Declaration, endorsed by Mediterranean countries in 2022 (FAO, 2022) and the Global Fire Management Hub.[13]

In this chapter, we provide an overview of wildfire activities in the Mediterranean region, focusing on key forest management strategies for prevention and post-fire restoration. We also explore recent trends in fire statistics, and international and regional cooperation and commitments. Additionally, we discuss future fire weather scenarios and the need for integrated restoration actions to build resilient landscapes.

By understanding the complex interplay between climate change, human activity and ecosystem dynamics, we can develop effective strategies to mitigate the impacts of wildfires and safeguard the ecological integrity of the Mediterranean region. Through collaborative efforts and innovative approaches (see the section on "International and regional collaboration" at the end of this chapter), we can work towards a more sustainable future for Mediterranean ecosystems and the communities that depend on them.

Current fire data

The fire statistics presented in this chapter have been produced continuing the information provided in the first edition of the State of Mediterranean Forests (FAO and Plan Bleu, 2013). In the first edition, statistics were provided from 2000 to 2010, and here we present the data from 2010 to 2023. The main difference from the first edition is that we have now limited the analysis to the areas covered by Mediterranean ecosystems as classified by Olson *et al.* (2001).

The main findings in the chapter subsections are:

- The Mediterranean region is divided into three subregions (Figure 5.1): the Western Mediterranean Countries (WMC), the Eastern Mediterranean Countries (EMC) and the Southern Mediterranean Countries (SMC).
- From 2010 to 2023, a total of 22 370 fires were reported in the Mediterranean region, with an average of more than 1 590 fires per year. Western Mediterranean countries accounted for 53 percent of the total number of fires.
- During the 2010–2023 period, more than 5.5 million hectares (ha) of land were burnt in the Mediterranean ecosystem area, averaging about 395 000 ha per year. Notably, 49 percent of the total burnt area was located in WM countries.
- Burnt forest areas accounted for about 34 percent and 35 percent of the area burnt in the WM and EM subregions, respectively, from 2010 to 2023.
- From 2010 to 2023, fires affected approximately 877 000 ha of protected areas in the Mediterranean region.
- In the WM and EM subregions, we found a positive relationship between a higher mean daily Fire Weather Index (FWI) and more area burnt.

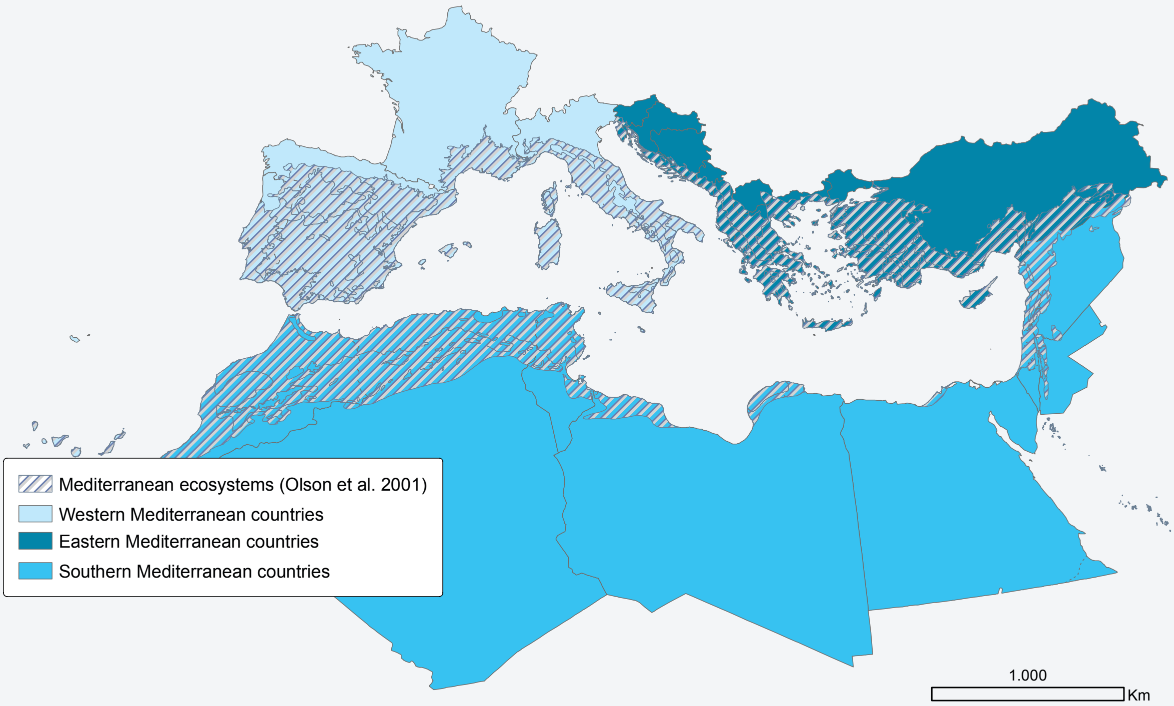
For the analysis of the spatial distribution of fire in the Mediterranean, we categorized countries into the same three subregions as in the State of Mediterranean Forests 2013 (Figure 5.1): the Western Mediterranean (WM), the Eastern Mediterranean (EM) and the Southern Mediterranean (SM). The WM comprises France, Italy, Portugal and Spain; the EM includes Albania, Bosnia and Herzegovina, Croatia, Cyprus, Greece, Montenegro, North Macedonia, Slovenia and Türkiye; and the SM consists of Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Palestine, the Syrian Arab Republic and Tunisia.

In the Mediterranean region, the five countries most prone to wildfires in Europe – France, Greece, Italy, Portugal and Spain – have forest fire data available from 1980 to 2023. However, data for other Mediterranean countries are often either unavailable or not freely accessible. The European Forest Fire Information System (EFFIS),[14] established by the Joint Research Centre (JRC)

[13] https://www.fao.org/partnerships/fire-hub

[14] https://forest-fire.emergency.copernicus.eu/

Figure 5.1. The Western, Eastern and Southern Mediterranean subregions



Notes: The striped area delineates the Mediterranean ecosystems as defined by Olson *et al.* (2001).

Refer to the disclaimer on page ii for the names and boundaries used in this map.

Sources: Olson, D.M., Dinerstein, E., Wikramanayake, E.D., Burgess, N.D., Powell, G.V.N., Underwood, E.C., D'amico, J.A. *et al.* 2001. Terrestrial *Ecoregions of the World: A New Map of Life on Earth. BioScience, 51(11): 933. https://doi.org/10.1641/0006-3568(2001)051[0933:TEOTWA]2.0.CO;2*

United Nations Geospatial. 2020. Map geodata [shapefiles]. New York, USA, United Nations

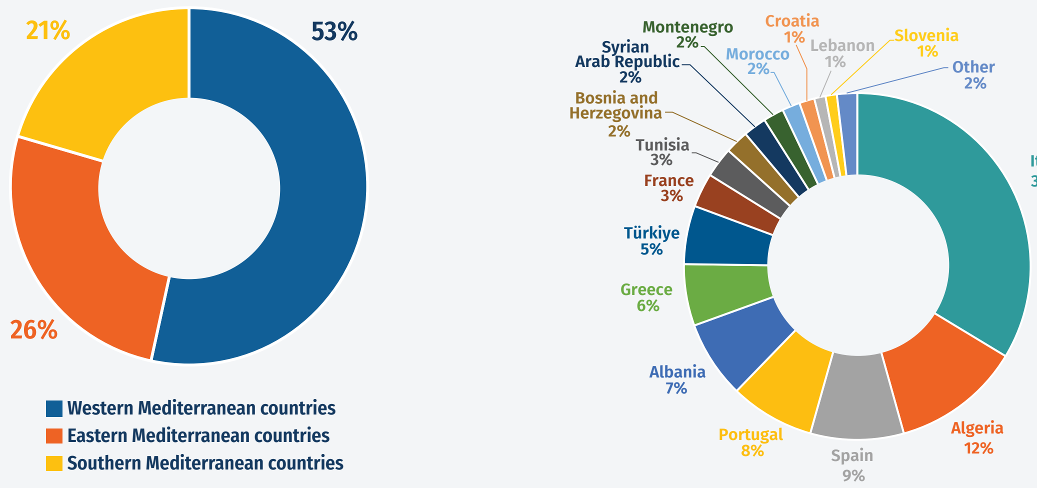
and the Directorate-General for Environment (DG ENV) of the European Commission to support fire management in Europe, is the main source of harmonized forest fire data, which are collected based on voluntary country submissions. Since 2010, EFFIS has included countries from the Near East and North Africa (NENA) in the data it collects on fire activity. The analyses in this chapter focus on the complete series of fire data from 2010 to 2023. Due to a lack of data, Egypt, Jordan and Palestine were excluded from the SM countries.

Number of fires in Mediterranean ecosystems in 2010–2023

From 2010 to 2023, a total of 22 370 fires were reported in the Mediterranean region, averaging over 1 590 fires per year. The WM countries accounted for 53 percent of the total number of fires, with approximately 13 250 fires reported, while EM countries ranked second at 26 percent (Figure 5.2a). Six countries – Italy, Algeria, Spain, Portugal, Albania and Greece – experienced 75 percent of all the fires that occurred in the Mediterranean region (Figure 5.2b). However, fire density, defined as the total number of fires per year per ten square kilometres (km^2) of Mediterranean ecosystem area, was higher in Slovenia, Montenegro, and Bosnia and Herzegovina (Figure 5.3).

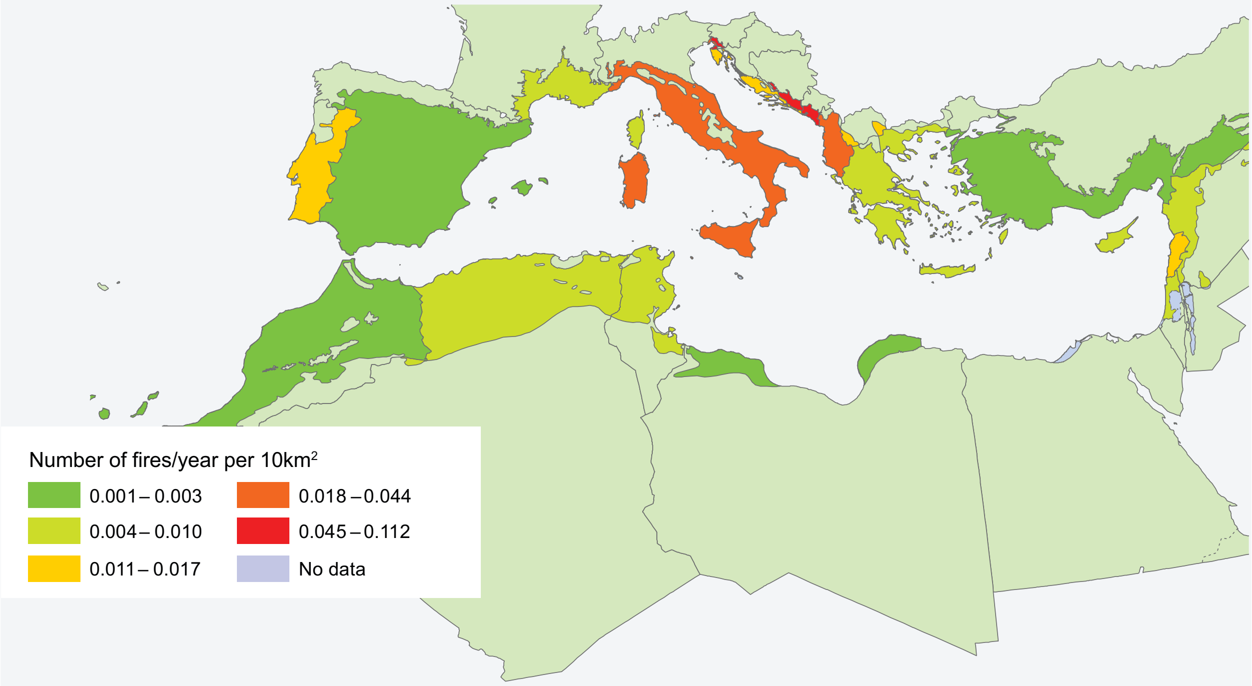
Upon analysing the 5-year mean number of fires (Figure 5.4) and focusing on those affecting more than 30 ha as in previous assessments, the WM countries exhibited a 41 percent increase in 2015–2019 compared to 2010–2014. The EM and SM subregions followed a similar trend (Figure 5.4a). Since 2019, EFFIS has incorporated data from Sentinel-2 to map daily burnt areas, allowing for the detection of much smaller fires. This has resulted in an increase in the number of fires detected, especially for the

Figure 5.2. (a) Percent share of fires by Mediterranean subregion, and (b) by country relative to the total number of fires reported for Mediterranean countries, 2010–2023



Sources: JRC. 2024. European Forest Fire Information System. [Accessed on 15 May 2025]. Licence: CC-BY-4.0., JRC. 2024. European Forest Fire Information System: European Fire Database. [Accessed on 15 May 2025]. Licence: CC-BY-4.0.

Figure 5.3. Fire density, Mediterranean region, 2010–2023



Notes: The regions shown in pale purple did not provide complete data on fire occurrence for the specified period. Fire density is the total number of fires per year per ten square kilometres of Mediterranean ecosystem area. Refer to the disclaimer on page ii for the names and boundaries used in this map.

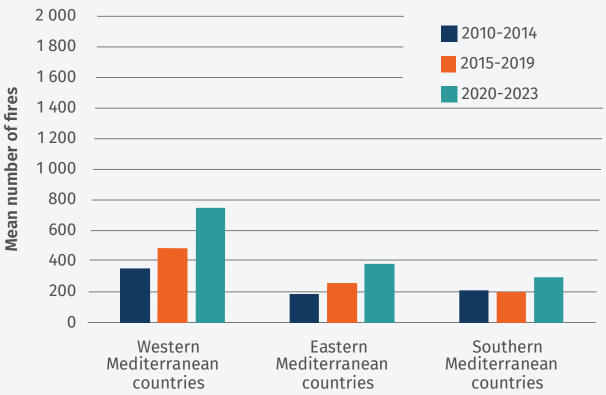
Sources: JRC. 2024. European Forest Fire Information System. [Accessed on 15 May 2025]. Licence: CC-BY-4.0. JRC. 2024. European Forest Fire Information System: European Fire Database. [Accessed on 15 May 2025]. Licence: CC-BY-4.0. United Nations Geospatial. 2020. Map geodata [shapefiles]. New York, USA, United Nations.

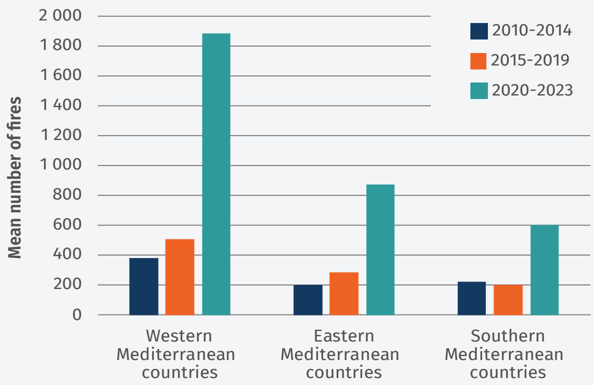
most recent period studied (Figure 5.4b). While this reflects advancements in satellite technology with higher spatial resolution, it is important to take these differences into account when drawing conclusions from different datasets.

Burnt area in Mediterranean ecosystems in 2010–2023

During the 2010–2023 period, more than 5.5 million ha of land were burnt in the

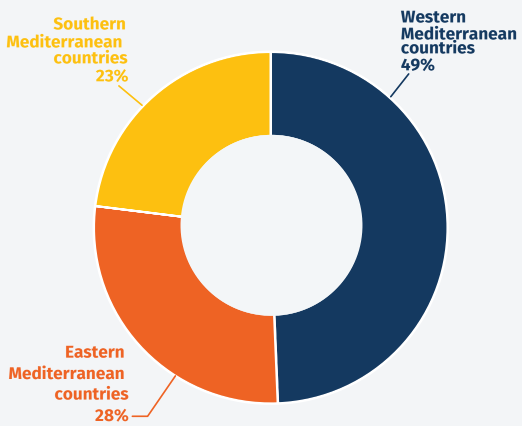
Figure 5.4. Average number of fires over a 5-year period for the three specified Mediterranean subregions, 2010–2023, (a) number of fires greater than 30 ha, and (b) total number of fires

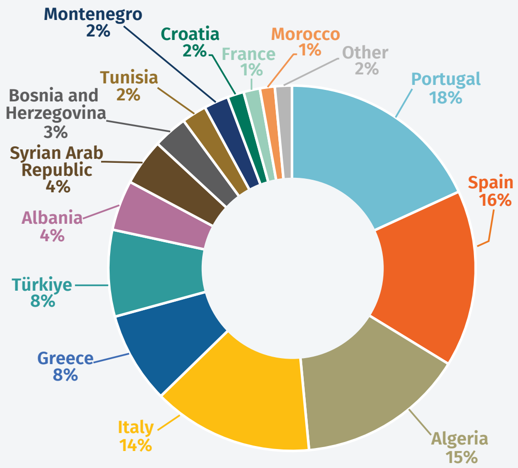




Sources: JRC. 2024. European Forest Fire Information System. [Accessed on 15 May 2025]. Licence: CC-BY-4.0.
JRC. 2024. European Forest Fire Information System: European Fire Database. [Accessed on 15 May 2025]. Licence: CC-BY-4.0.

Figure 5.5. (a) Percent share of burnt area by Mediterranean subregion, and (b) by country relative to the total burnt area reported for Mediterranean countries, 2010–2023



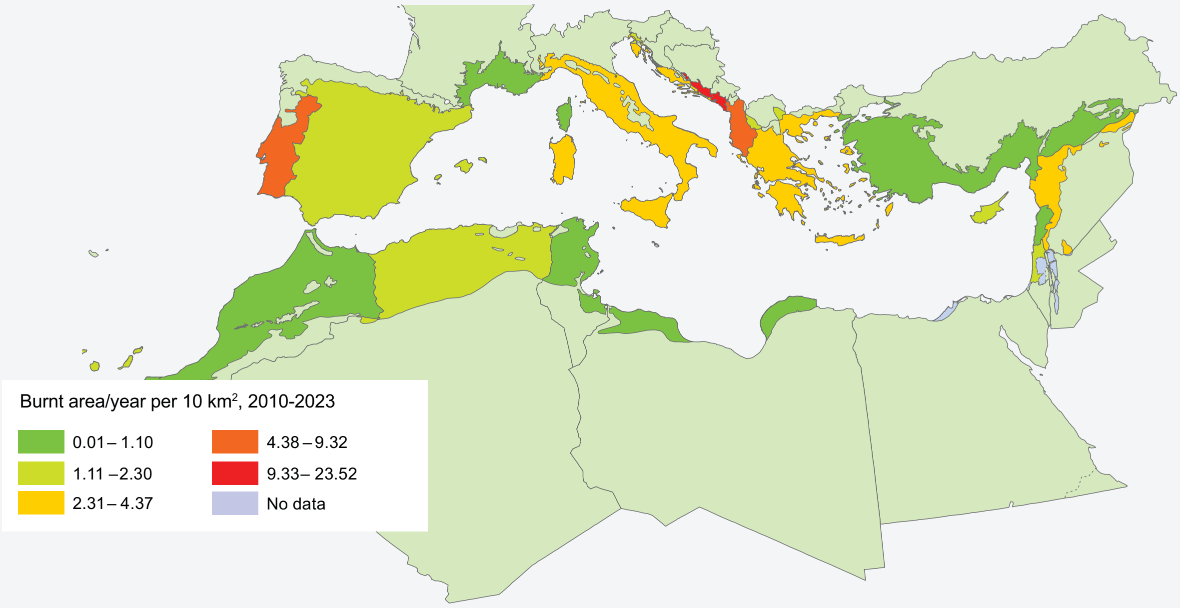


Souces: JRC. 2024. European Forest Fire Information System. [Accessed on 15 May 2025]. Licence: CC-BY-4.0.
JRC. 2024. European Forest Fire Information System: European Fire Database. [Accessed on 15 May 2025]. Licence: CC-BY-4.0.

Mediterranean ecosystem area, averaging approximately 395 000 ha per year. Notably, 49 percent of the total burnt area was located in WM countries (Figure 5.5). This is much higher than in EM and SM countries, which accounted for 28 percent and 23 percent of the total burnt area, respectively (Figure 5.5). Figure 5.6 shows that five countries – Portugal, Spain, Italy, Algeria and Greece – accounted for over 70 percent of the burnt area, which included other wooded lands, agriculture and artificial areas.

The burnt area in the region shows strong annual variations. The countries with the highest proportion of annual burnt area relative to their total land within the Mediterranean ecosystem area for the 2010–2023 period were Bosnia and Herzegovina, Montenegro, Albania and Portugal (Figure 5.6), highlighting the significant fire impact

Figure 5.6. Burnt area per year in the Mediterranean region, 2010–2023



Notes: The areas shown in pale purple did not provide complete data on burnt areas for the specified period. Burnt area is given in hectares burnt per year per ten square kilometres of Mediterranean ecosystem area.
Refer to the disclaimer on page ii for the names and boundaries used in this map.

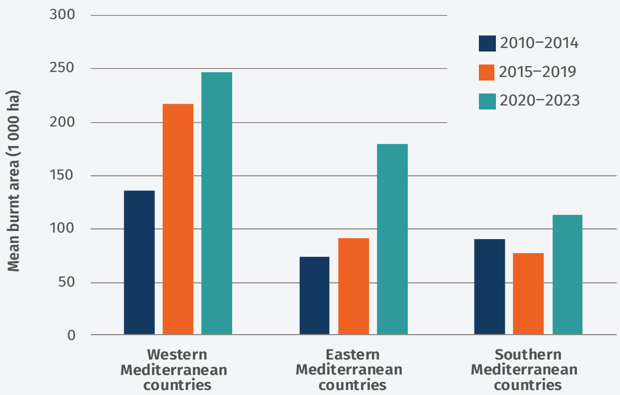
Sources: JRC. 2024. European Forest Fire Information System. [Accessed on 15 May 2025]. Licence: CC-BY-4.0.
JRC. 2024. European Forest Fire Information System: European Fire Database. [Accessed on 15 May 2025]. Licence: CC-BY-4.0., United Nations Geospatial. 2020. Map geodata [shapefiles]. New York, USA, United Nations.

that these countries experience in relation to their area of Mediterranean ecosystems.

Analysis of the 5-year mean burnt areas reveals that WM countries saw a significant increase of 61 percent from 2010–2014 to 2015–2019, whereas SM countries experienced a slight decrease of 14 percent (Figure 5.7). However, the 2020–2023 period is characterized by a pronounced rise in mean burnt area, especially in EM countries (Figure 5.7).

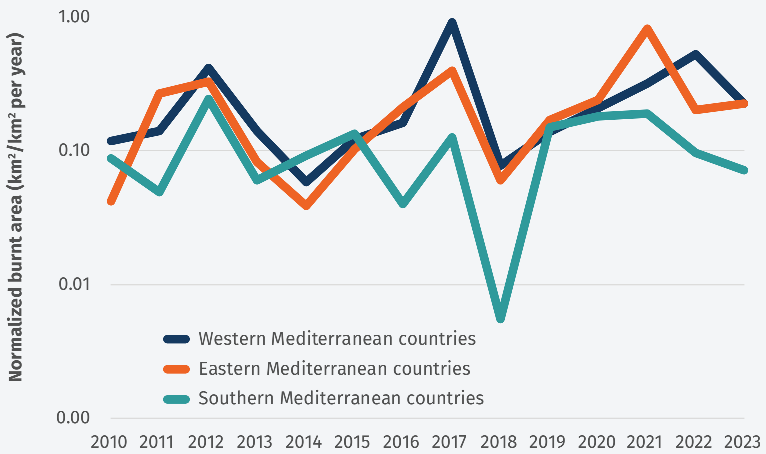
Figure 5.8 displays the annual series of burnt area normalized by the corresponding study area (in km²). Although data from the analysed period does not show any statistically significant trends, a visual inspection reveals a slight increase in burnt areas in EM and WM countries as well as considerable year-to-year variability in SM countries.

Figure 5.7. Average burnt area over a 5-year period for the three specified Mediterranean subregions, 2010–2023



Sources: JRC. 2024. European Forest Fire Information System. [Accessed on 15 May 2025]. Licence: CC-BY-4.0., JRC. 2024. European Forest Fire Information System: European Fire Database. [Accessed on 15 May 2025]. Licence: CC-BY-4.0.

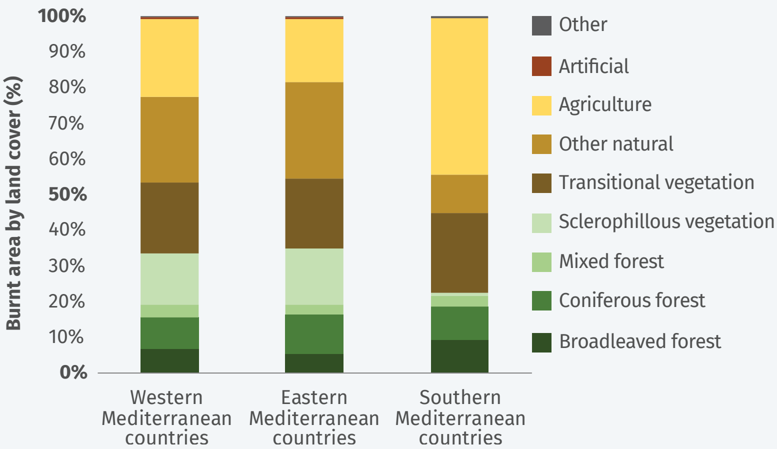
Figure 5.8. Annual burnt area series in the three specified Mediterranean subregions, normalized by Mediterranean ecosystem area



Note: Ordinates are on a logarithmic scale (log10).

Sources: JRC. 2024. European Forest Fire Information System. [Accessed on 15 May 2025]. Licence: CC-BY-4.0.,
JRC. 2024. European Forest Fire Information System: European Fire Database. [Accessed on 15 May 2025]. Licence: CC-BY-4.0.

Figure 5.9. Percent share of burnt area, by land cover, for the three specified Mediterranean subregions, 2010–2023



Sources: JRC. 2024. European Forest Fire Information System. [Accessed on 15 May 2025]. Licence: CC-BY-4.0.,
JRC. 2024. European Forest Fire Information System: European Fire Database. [Accessed on 15 May 2025]. Licence: CC-BY-4.0.

Burnt area by land cover and protected areas in Mediterranean ecosystems in 2010–2023

During the 2010–2023 period, more than 1.7 million ha of forest, including broadleaved, coniferous and mixed forest and sclerophyllous vegetation, and over 1.4 million ha of agricultural land were burnt in the Mediterranean ecosystem area.

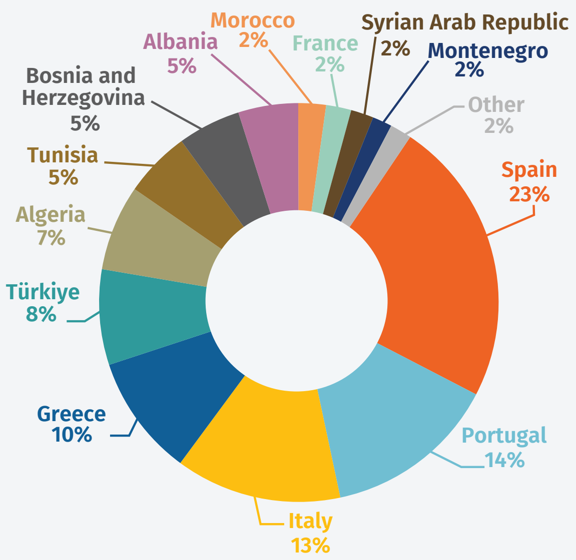
In the WM and EM subregions, forest areas accounted for about 34 percent and 35 percent of the total area burnt, respectively, while in SM countries, they represented 22 percent. Within forest areas, the percentage of sclerophyllous vegetation that was burnt was higher in the WM and EM subregions, at 43 percent and 45 percent, respectively, compared to other forest types (Figure 5.9). The share of agricultural land that was burnt relative to the total burnt area ranged from 44 percent in SM countries to 18 percent in EM countries. On the other hand, in EM countries, other natural areas accounted for a relatively large share of the total burnt area at 27 percent (Figure 5.9).

Focusing specifically on the area of burnt forest, WM countries made up 52 percent of the total forest area affected, with Spain alone accounting for 23 percent of the total forest area burnt in the region (Figure 5.10).

Figure 5.11 displays 5-year mean burnt areas by land cover for the three subregions analysed. In WM countries, the mean burnt forest area increased by 145 percent, from about 40 360 ha in 2010–2014 to 98 840 ha in 2020–2023. The EM and SM countries experienced even greater increases in forest burnt area, by 270 percent and 230 percent, respectively, between 2010–2014 and 2020–2023.

From 2010 to 2023, fires affected approximately 877 000 ha of protected areas. Figure 5.12 shows the total protected areas that were burnt in relation to the total area burnt, which ranged from a maximum of 27 percent in WM countries (about 747 000 ha) to a minimum of 3 percent in SM countries (about 42 000 ha).

Figure 5.10. Percent share of the total burnt forest area reported for Mediterranean countries, by country, 2010–2023



Sources: JRC. 2024. European Forest Fire Information System. [Accessed on 15 May 2025]. Licence: CC-BY-4.0
JRC. 2024. European Forest Fire Information System: European Fire Database. [Accessed on 15 May 2025]. Licence: CC-BY-4.0.

Burnt area and fire weather

Although fire events in the region are closely linked to human activity, meteorological conditions play a key role in the development of large, intense and simultaneous fires (San-Miguel-Ayanz, Moreno and Camia, 2013; Calheiros, Nunes and Pereira, 2020). Fire weather has historically been used to estimate fire danger, with the former defined as the meteorological conditions that are conducive to the latter (Schroeder and Buck, 1970). Burnt areas have been directly linked to elevated values of fire weather as represented by different fire weather indices (Camia and Amatulli, 2009; Ertugrul *et al.*, 2019; Moreira *et al.*, 2020). In the Mediterranean, there is a close relationship between fire weather and the interannual variability in burnt area (Jones *et al.*, 2022). Among the various indices used to estimate fire weather, the Canadian Fire Weather Index System (CFWIS) (Van Wagner, 1987) is one of the most widely used. Using the FWI component, which represents the general index of fire danger of the CFSWIS, we found that a proportion of the interannual change in the burnt area could be significantly (p-value < 0.05) explained by changes

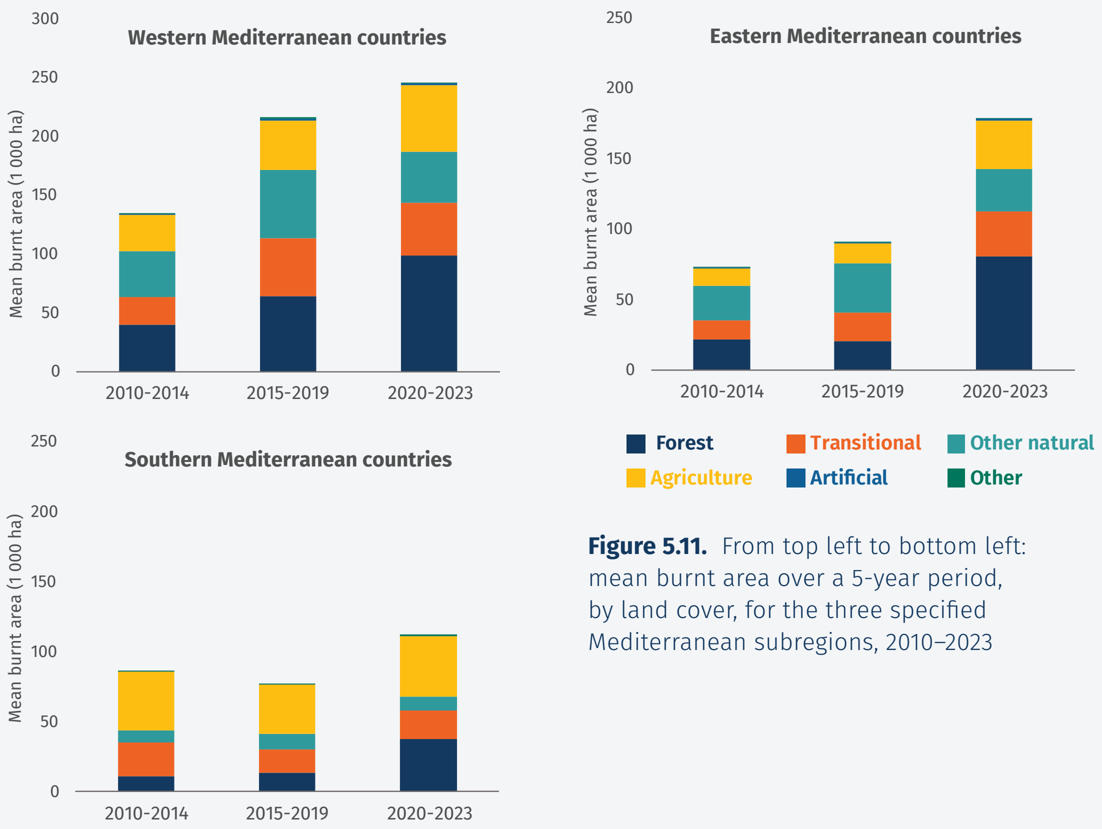
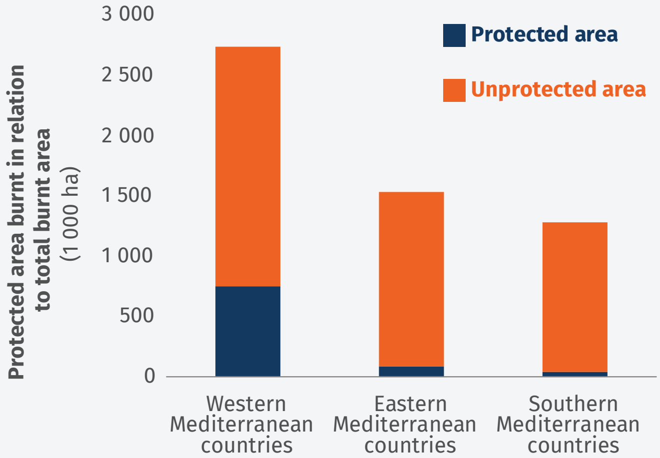


Figure 5.11. From top left to bottom left: mean burnt area over a 5-year period, by land cover, for the three specified Mediterranean subregions, 2010–2023

Sources: JRC. 2024. European Forest Fire Information System. [Accessed on 15 May 2025]. Licence: CC-BY-4.0
JRC. 2024. European Forest Fire Information System: European Fire Database. [Accessed on 15 May 2025]. Licence: CC-BY-4.0.

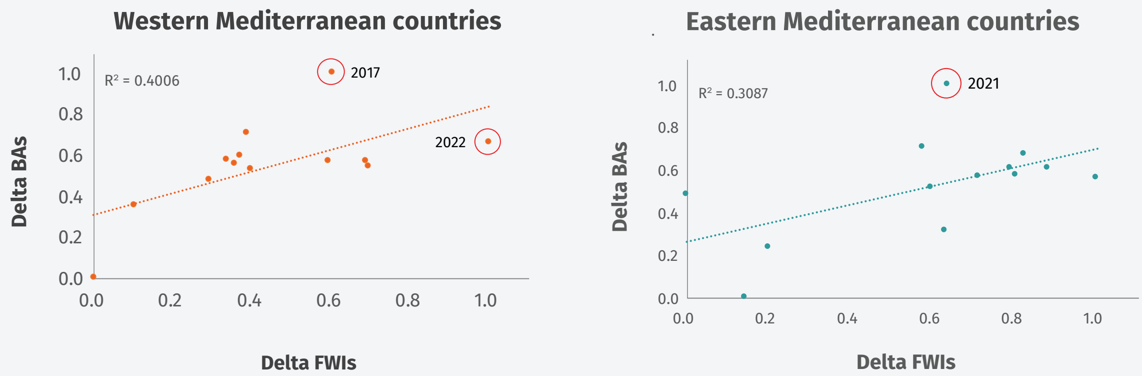
Figure 5.12. Total protected area burnt in relation to the total area burnt in the three specified Mediterranean subregions, 2010–2023



Sources: JRC. 2024. European Forest Fire Information System. [Accessed on 15 May 2025]. Licence: CC-BY-4.0,
JRC. 2024. European Forest Fire Information System: European Fire Database. [Accessed on 15 May 2025]. Licence: CC-BY-4.0.

in fire weather in the Mediterranean region (Figure 5.13). High mean daily FWI values were associated with conditions where fires could become intense and severe, and thus potentially more damaging (Jones *et al.*, 2024). Looking at all fire types during the fire season in the region (May–October), more severe fire seasons with higher mean daily FWI values were associated with larger burnt areas, such as in WM countries in 2017 and 2022, and in EM countries in 2021 (Figure 5.13). The association is weaker for SM countries (not shown).

Figure 5.13. Total area burnt and fire weather (indexed using the Canadian Fire Weather Index, FWI) in Western and Eastern Mediterranean countries during the fire season, May-October, 2010–2022



Notes: The data are detrended with the first-difference method,* and changes are standardized from 0 to 1.†,‡

Sources: FWI data from: Copernicus Climate Change Service (2019). Climate Data Store: Fire danger indices historical data from the Copernicus Emergency Management Service. [Accessed on 5 June 2025]. https://doi.org/10.24381/cds.0e89c522, * Lobell, D.B. & Field, C.B. 2007. Global scale climate–crop yield relationships and the impacts of recent warming. *Environmental Research Letters*, 2(1): 014002. https://doi.org/10.1088/1748-9326/2/1/014002, † Moreira, F., Ascoli, D., Safford, H., Adams, M.A., Moreno, J.M., Pereira, J.M.C., Catry, F.X. *et al*. 2020. Wildfire management in Mediterranean-type regions: paradigm change needed. *Environmental Research Letters*, 15(1): 011001. https://doi.org/10.1088/1748-9326/ab541e, ‡ Ascoli, D., Plana, E., Oggioni, S.D., Tomao, A., Colonico, M., Corona, P., Giannino, F. *et al*. 2023. Fire-smart solutions for sustainable wildfire risk prevention: Bottom-up initiatives meet top-down policies under EU green deal. *International Journal of Disaster Risk Reduction*, 92: 103715. https://doi.org/10.1016/j.ijdrr.2023.103715

Climate change scenarios for future fire activity

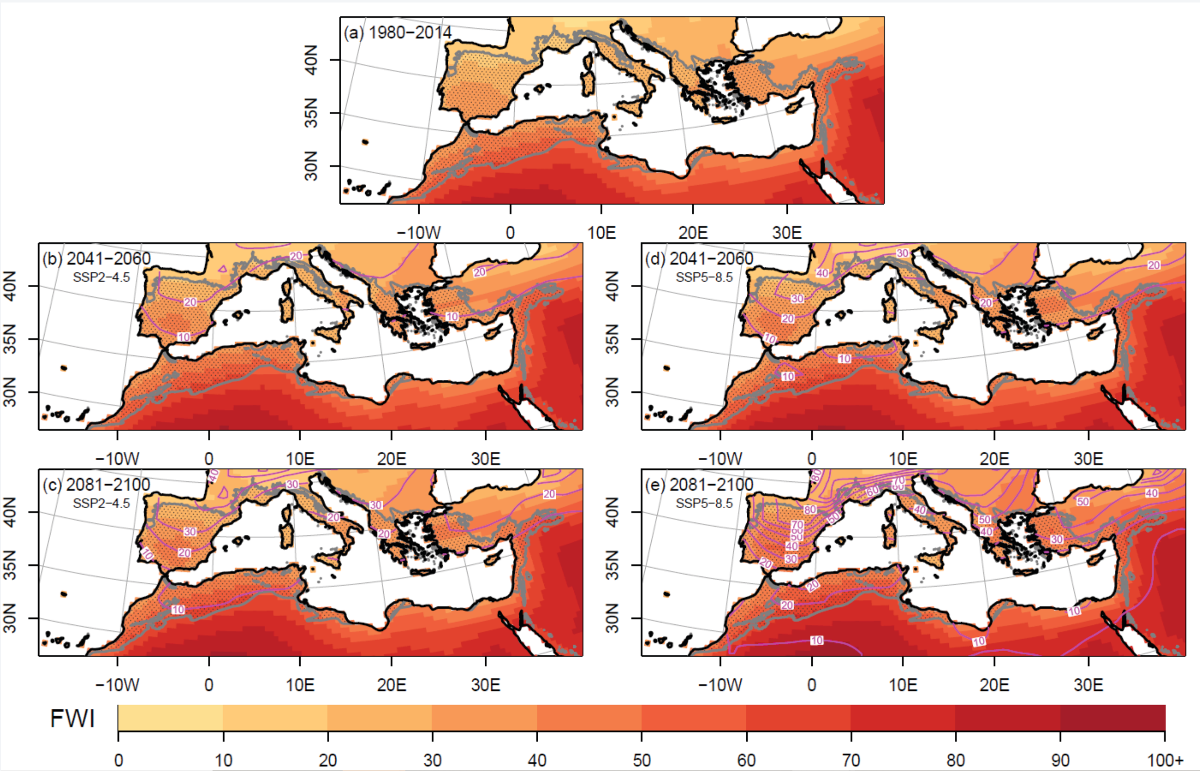
The Mediterranean region is one of the areas most vulnerable to climate change, warming at a 20 percent faster rate than the global average (MedECC, 2020). Various climate change scenarios for the twenty-first century predict warming temperatures and decreasing precipitation in the region (Tuel and Eltahir, 2020; Cos *et al.*, 2022; Mirgol *et al.*, 2024).

Given the relationship between fire and weather conditions, fire activity is also expected to increase under these projections. Several studies have already projected an increase in the length of the fire season (Moriondo *et al.*, 2006), more frequent extreme fire weather events (Moriondo *et al.*, 2006; Giannakopoulos *et al.*, 2009) and a general increase in fire weather values (Moriondo *et al.*, 2006; Giannakopoulos *et al.*, 2009; Bedia *et al.*, 2015).

Specifically, studies using different models have projected an increase in fire weather intensity and frequency in two Representative Concentration Pathways (RCP4.5 and RCP8.5), and a lengthening of the fire weather season (Jones *et al.*, 2022). More recently, Gallo *et al.* (2024) also found that higher fire weather values are expected in the region by the end of the century under two different Shared Socioeconomic Pathways (SSP2-4.5 and SSP5-8.5) (Figure 5.14), especially in WM and EM countries.

Regarding the number of fires and area of land affected, different studies have projected an increase in the number of wildfires due to weather

Figure 5.14. (a) Historical simulations of the annual maxima in 90-day running mean Fire Weather Index (FWI), averaged for 1980–2014; (b) FWI annual maxima in 90-day running mean under SSP2-4.5 averaged over 2041–2060; and (c) 2081–2100. (d-e) As for (b) and (c) but for SSP5-8.5



Notes: Grey-dotted areas represent Mediterranean ecosystems. Contour lines indicate percentage change in FWI with respect to 1980–2014. Refer to the disclaimer on page ii for the names and boundaries used in this map.

Source: Gallo, C., Bacciu, V., Bedhiaf, S., Dieppois, B., Fulé, P., Kavgacı, A., Steil, L. & Eden, J. 2024. Mediterranean fire weather and restoration perspectives in a changing climate. *Unasylva*, 255(75): 58–68. Rome, FAO. https://doi.org/10.4060/cd1720en conditions more favourable to fires under RCP4.5 and RCP8.5 (e.g. Ruffault *et al.* [2020]), and an increase in burnt area under RCP2.6 and RCP6.0, with some areas showing expected decreases in North Africa (UNEP, 2022).

Future research and decision-making should focus on identifying the most vulnerable areas to these projected changes at a finer spatial scale. These future scenarios, in which fire activity is expected to increase, must be considered in the coming years when designing policies and developing forest and fire management plans, particularly in prevention and restoration strategies.

Strategies and good practices on wildfire prevention and post-fire restoration

Wildfire prevention

Wildfire prevention, also known as fire risk reduction, encompasses activities aimed at reducing the likelihood of wildfires and limiting their intensity in order to optimize firefighting capacity and security, enhance safety, and mitigate the severity of fire impacts on ecosystem services. Considering future fire weather projections, the following measures can support wildfire prevention directly or indirectly:

- **Vegetation and forest management for fuel reduction or removal**: fuel breaks to support firefighting, including water points and track maintenance; silvicultural practices to increase the fire resilience of forest stands, such as variable retention harvest, pruning, thinning, and prescribed burning and grazing; and defensive infrastructure at the wildland–urban interface.
- **Indirect prevention** by promoting integrated landscape management and rural development in fire-prone areas (Bacciu, Sirca and Spano, 2022; Ascoli *et al.*, 2023; Pulido *et al.*, 2023).
- **Wildfire regulations, strategies and planning** at the national, regional and local levels.
- **Regulation and planning of traditional fire use**, such as pastoral fires for grazing management.
- **Data collection**, wildfire statistics and investigation of causes.
- **Establishment of prevention brigades** to reconcile interests with the rural population, raise awareness and perform fuel reduction activities.
- **Estimation of wildfire risk**, innovative planning and prediction of wildfire occurrence using up-to-date geospatial techniques, simulation and artificial intelligence.

Wildfire prevention in the Mediterranean region has recently been addressed in the document “Key Recommendations on Wildfire Prevention in the Mediterranean” (Mauri *et al.*, 2023), which updates the “Position Paper on Wildfire Prevention in the Mediterranean” (FAO, 2011). This document emphasizes that wildfire prevention must be integrated as a crucial tool for effective wildfire management, and key recommendations are provided for this purpose, focusing on six topics: integrated planning, governance models, sustainable financial mechanisms, knowledge generation and awareness, harmonization of information, and international cooperation. The document outlines key actions for land managers to consider in forest management planning:

A. Analyse and identify strategic management zones, based on the study of historic wildfires, topography and fuel models.

B. Manage fuel, considering all possible techniques depending on the context and specific needs, to limit wildfire risks (such as biomass reduction and prescribed burning).

C. Use forest infrastructure for fire suppression (such as roads and water points).

D. Integrate social prevention measures (such as public awareness and local participation).

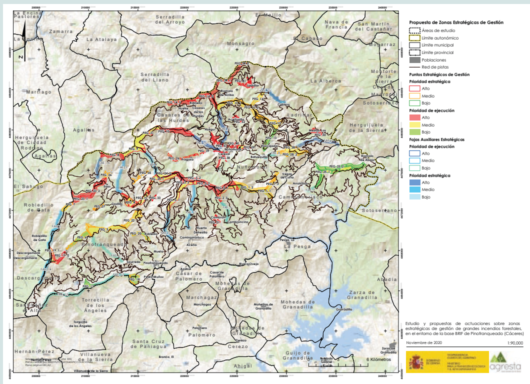
E. Integrate spatial planning (such as urban planning and land management).

Table 5.1 provides details of two success stories on effective fire prevention in Italy (case 1) and in Spain (case 2).

Table 5.1 Good practices in wildfire prevention

	Case 1. The cultural use of fire for prevention in agropastoral systems, Italy	Case 2. Defining strategic management zones to maximize the efficiency of wildfire prevention actions, Spain
Context	The cultural use of fire for agricultural and pastoral practices was once common in the island of Sardinia, Italy, where it was employed to control weeds, remove woody shrubs, and facilitate livestock grazing. However, the progressive decline of pastoralism and agriculture in the twentieth century has led to the gradual abandonment of this practice and the loss of related technical knowledge. This change has been compounded by the laws on fire regulation and fire prescriptions, which mainly adhere to a "zero-fire" policy. Planargia is a historical subregion in central-western Sardinia, characterized by pastures and agroforestry areas, which feature superficial rocks and stones, and extensive non-arable land. Between 2002 and 2011, an average of 27 fires burned 340 hectares (ha) per year in the area, occasionally caused by pastoral fires lit to rejuvenate pastures, resulting in significant yearly costs.[i] In 2012, the Sardinia Forest Service (CFVA) initiated the "Planargia Fire Management Plan", which provides detailed guidelines for designing and implementing methods for conducting prescribed burning.	Spain is made up of four biogeographical regions. Eighty five percent of its territory is located in the Mediterranean region. Between 2019 and 2023, an average of 5 000 wildfires occurred per year in the Spanish Mediterranean region, burning an average of 57 000 ha of forest land (both wooded and non-wooded). In this context, the Spanish Ministry for Ecological Transition and Demographic Challenge (MITECO), in collaboration with the autonomous communities, has put in place several innovative planning initiatives to maximize the efficiency of wildfire prevention actions in the country. Among these initiatives are the prediction of wildfire risk using an artificial intelligence application called ARBARIA, and the establishment of strategic management zones (SMZs).
Objectives and actions	The objective of the fire management plan was to reduce uncontrolled burning and large wildfires, while also considering the cultural and social use of fire in the area as a means of improving the quality and palatability of grass species for livestock. The CFVA held meetings with local actors and government agencies to discuss social conflicts related to land use and fire management before outlining the planned interventions. The controlled burning plan included the following components: i) an analysis of environmental constraints to consider for intervention design; ii) a socioeconomic analysis along with essential management strategies to limit the impact of smoke on communities; iii) an analysis of fire regimes to identify areas of higher hazard and risk; and iv) a detailed fuel analysis and estimation of potential fire behaviour based on field surveys and existing data. The interventions included providing training for personnel involved in wildfire prevention and control, specifically on building anchor lines using blowers, sprayers and water pumps to deliver enough water and foaming products.	Due to resource limitations, wildfire prevention actions, including preventive forestry, building defensive infrastructure, prescribed burning and grazing, should be prioritized through strategic planning to maximize their effect on reducing the impacts of wildfires. The establishment of SMZs aims to "prioritize areas according to a specific methodology that takes into account fire vulnerability, risk and behaviour, which makes it possible to establish and optimize the spatial and temporal planning of fuels and infrastructure to limit the risk of wildfires, while detecting suppression opportunities and anticipating an effective and safe strategy for large wildfires".[ii] The SMZs are mainly delimited using topographic and fuel maps, meteorological variables, infrastructure information and historical records of wildfire occurrence in the area, the latter being essential to plan prevention measures.* Once the data sources were combined, a series of simulations were performed to identify propagation nodes (places where propagation axes, with minimum travel time, accumulate for different meteorological scenarios), and critical points (areas where the fire front arrives, resulting in a negative change of behaviour).

	Case 1. The cultural use of fire for prevention in agropastoral systems, Italy	Case 2. Defining strategic management zones to maximize the efficiency of wildfire prevention actions, Spain
Outcomes	The prescribed fire programme has significantly reduced the number of fires (down by 88 percent), the area burnt (down by 91 percent), and the cost of aerial resources (down by 89 percent), as shown when comparing the periods 2002–2011 and 2011–2022. The plan for prescribed burning included training on the prescribed fire technique, and encouraged establishing and improving teamwork while promoting a responsible approach to land management. Prescribed burning before the rainy season promoted the growth of palatable annual herbaceous vegetation for livestock, such as grasses from the *Hordeum* and *Lolium* ssp. as well as some legumes, thus ensuring a low-cost resource essential for extensive sheep farming.[i]	The SMZs were established by integrating all relevant spatial information and expert criteria. They specify various levels of priority and suggest a range of preventive actions that should be implemented. MITECO is collaborating with the Forest Science Institute of the Spanish National Research Council's National Institute for Agricultural and Food Research and Technology (INIA-CSIC) on a wildfire prevention project with two interconnected areas of focus: evaluating the effectiveness of SMZs and the National Programme for Experimental Prescribed Burning. In the Mediterranean forest district of Las Hurdes, located in Cáceres Province, SMZs were established (see figure below) and submitted to the regional government for future planning of prevention actions.
Main lessons learned	- Prescribed fire has the potential to mitigate fire impacts when planned collaboratively with local stakeholders for the medium term. - The number of ignitions and the area burnt were reduced, along with firefighting costs and conflicts between the local communities and the CFVA. - The fire management plan provided valuable opportunities for training firefighters in controlled conditions.	- Innovative planning initiatives are needed to maximize the efficiency of wildfire prevention actions in Mediterranean areas. - The delineation of SMZs allows for the prioritization of specific areas and targeted actions that are most suitable for each area. - The SMZs should be taken into account by government authorities and land managers when deciding which preventive actions to implement.



Note:

* In Spain, the most reliable source of information is the General Statistics of Forest fires (Estadística General de Incendios Forestales, EGIF), a comprehensive and longstanding database that records all the wildfires that have occurred in Spain since 1968.
Refer to the disclaimer on page ii for the names and boundaries used in this map.

Sources:

[i] Cabiddu, S., Cuccu, G.M., Pinna, T.M., Casula, A., Magari, L., Putzulu, G., Pala, E. et al. 2023. El uso cultural del fuego y sus efectos positivos en regiones agropastorales mediterráneas. *Revista Incendios y Riesgos Naturales*, 10: 35–38. https://hdl.handle.net/20.500.14243/463612

[ii] SECF (Sociedad Española de Ciencias Forestales). 2019. *Definición y recomendaciones técnicas en el diseño de puntos estratégicos de gestión: "Decálogo de Valencia" para la defensa integrada frente a los incendios en la gestión del mosaico agroforestal*. J. Madrigal, M. Romero-Vivó & F. Rodríguez y Silva, eds. Generalitat Valenciana.

Post-fire restoration

Post-fire restoration is essential for natural areas affected by wildfires, such as forest stands, which provide key ecosystem services, like landslide protection and soil cover. When fire disturbance reduces their ability to provide these services, such as when certain plant species struggle to regenerate after a fire, restoration actions are needed to help recover functionality. Post-fire restoration refers to the process of recovering ecosystem functions that have been degraded, damaged or destroyed by a wildfire. It comprises a range of actions, such as managing dead trees, soil preparation, seeding, pruning, clearing, managing vegetation (e.g. controlling invasive exotic species), controlling pests, preventing erosion and restoring hydrological functions.

Various post-fire restoration measures have been implemented throughout the Mediterranean region. To collect initiatives and capitalize on good practices in post-fire restoration, the country members of the Committee on Mediterranean Forestry Questions – *Silva Mediterranea*[15] of FAO received a contribution from the Multipartner Trust Fund in the context of the United Nations Decade on Ecosystem Restoration 2021–2030, as part of the broader existing Mediterranean Flagship Initiative. Stakeholders involved in wildfire management in the region benefit from knowledge sharing and the collection of effective practices in post-fire restoration under this initiative. Examples of post-fire restoration practices already being applied in the region are shown in Table 5.2, with one in Lebanon (case 3) and one in Türkiye (case 4).

Investment combined with proper monitoring and maintenance is essential for successful post-fire restoration. Forest strategies and legislation need to provide for post-fire restoration activities to be carried out under specific conditions. For instance, the Spanish Forest Law (*Ley de Montes*, 2003) requires that governments ensure the necessary conditions for the restoration of forest land affected by wildfires. Additionally, the “Strategic guidelines for wildland fire management in Spain” (MITECO, 2022) emphasize that investments in post-fire restoration should aim to create landscapes that are more resistant and resilient to wildfires. Mauri *et al.* (2023) recommend that data are collected on the costs of prevention, suppression and restoration to achieve balanced investments in each area.

[15] https://www.fao.org/silva-mediterranea/en

Table 5.2. Good practices in post-fire restoration

	Case 3. Piloting a post-fire restoration plan in a *Pinus brutia* forest, Lebanon	Case 4. Restoring the Bodrum forest after the 2006 wildfire, Türkiye
Context	Akkar El Attika is located in the northernmost part of Lebanon and features diverse ecosystems and significant forested areas, including valuable stands of *Pinus brutia*. This region has faced numerous challenges due to wildfires, which have increasingly impacted the landscape, biodiversity and local communities. Recognizing the need for effective response strategies, a pilot post-fire restoration plan was developed, combining international guidance, national support and local expertise. The plan was implemented by the United Nations Development Programme (UNDP) and the Ministry of Environment under the GEF-funded project "Land Degradation Neutrality for Mountain Landscapes in Lebanon". The plan is intended to address immediate challenges like post-fire soil erosion and habitat loss, serving as a guiding framework for national and local stakeholders.	Bodrum is located along the southwestern coast of Türkiye's Aegean Region, near the ancient city of Halicarnassus. Due to its historical importance and natural beauty, it has become a popular tourist destination. Bodrum has a typical Mediterranean climate with hot summers and mild winters. The average temperature is around 15 °C in winter and 34 °C in summer, with temperatures often reaching up to 46 °C in July and August. Rainfall is relatively abundant in winter, but the summers are relatively dry. The Bodrum forest fire started on 21 June 2006 and lasted 30 days, affecting 2 601 hectares (ha) of Turkish red pine (*Pinus brutia*) forest.
Objectives and actions	The primary objective was to initiate a pilot post-fire restoration process in Akkar El Attika, focusing on immediate soil stabilization and long-term ecosystem recovery, by: - conducting an evaluation and site assessment; - designing and planning the restoration process; - stabilizing the soil using log erosion barriers (LEBs); - involving the community in restoration efforts; - carrying out monitoring and evaluation for adaptive management; and - publishing a guidebook on post-fire soil erosion protection in Lebanon.	Out of the total burnt area, 1 971 ha regenerated naturally. Active restoration was implemented on 245 ha by sowing 385 kilograms (kg) of red pine seeds and planting 410 000 red pine saplings.
Outcomes	- The use of LEBs proved to be effective in significantly reducing soil loss on steep slopes and in burnt areas, and thus was found to promote natural regeneration. - Soil quality and moisture retention were improved. - Community engagement and awareness about ecosystem conservation and fire prevention were strengthened, which establishes a solid foundation for implementing effective post-fire restoration plans in Lebanon.	- Mixed stands with coniferous and broadleaved tree species were established instead of pure stands. - Restoration activities in the stands were partially managed, and the stand sizes needed to be within the range of 300–500 ha. - Fire strips and buffer zones with less flammable broadleaved native plants and cypresses were established at the wildland–urban interface.

	Case 3. Piloting a post-fire restoration plan in a *Pinus brutia* forest, Lebanon	Case 4. Restoring the Bodrum forest after the 2006 wildfire, Türkiye
Main lessons learned	- Soil stabilization: the effectiveness of LEBs highlights the importance of proven, low-cost techniques in post-fire restoration efforts. - Community engagement: the active involvement of local communities not only enhances the implementation of restoration actions but also fosters a sense of ownership and responsibility towards the natural environment. - Integrated approach: addressing both immediate (soil stabilization) and long-term (habitat recovery) needs is essential for the resilience of fire-affected areas. - Monitoring: continuous monitoring allows for the adjustment of restoration strategies in response to observed outcomes and emerging challenges, ensuring the effectiveness of the restoration efforts over time.	- Post-fire restoration is crucial to rehabilitate ecosystems, support affected communities and mitigate potential hazards after a wildfire. - Post-fire forest restoration is a must for maintaining the ecological integrity of forests and improving the sustainability of affected forest landscapes. - Fostering collaboration among government agencies, non-governmental organizations, academic institutions and local communities is essential for leveraging resources, expertise and collective action in post-fire restoration initiatives.

International and regional collaboration

International and regional collaboration in the Mediterranean is extensive, with multiple initiatives involving international organizations, national governments, research centres, academia and the private sector. Globalization, more accessible information and advancements in communication technologies have facilitated a continuous flow of information and the exchange of experiences and knowledge, leading to growing collaboration in recent years.

Current collaboration mechanisms cover all phases of landscape fire management, including detection, prevention, preparedness, suppression and recovery, and involve multiple disciplines and several sectoral areas, such as research and development, new technologies, applied meteorology, fire ecology, civil protection and climate change. Numerous initiatives at different levels and with different regional scopes aim to connect experts and capitalize on experiences. These increased exchanges also stem from a rise in complex landscape fire situations where countries needed to request assistance from outside their borders or increase their knowledge on specific topics.

Despite this level of collaboration, challenges remain. One key challenge is finding synergies between the different initiatives that will help strengthen them and ensure the most effective use of resources and efforts. The regional approach in the Mediterranean area, which relies on existing networks, is an example of this, but one which needs a higher level of coordination and integration.

The discipline known as fire investigation (de Ronde and Goldammer, 2015) is a critical area for international and regional collaboration. Understanding the causes and motivations behind intentional fires and the main factors leading to accidental fires is essential for developing effective prevention policies. In current and future global change scenarios, prevention policies, including silvicultural practices, are becoming even more relevant, as they are necessary to reduce the number of ignitions and minimize their occurrence during periods that could have the most severe consequences, potentially leading to complex situations.

In the case of complex fire scenarios that require international assistance, one of the key areas for collaboration is fire behaviour analysis. Enhanced knowledge and strengthened systems in this area will enable a shift from a merely reactive approach, which focuses on dispatching suppression means, to a more proactive one that involves analysing fires, identifying genuine suppression opportunities and efficiently allocating resources and tasks.

Complex fire scenarios will continue to arise, and the exchange of knowledge, expertise and resources must be better prepared beforehand to allow for actions before, during and after fire events. Therefore, the primary focus of international and regional initiatives in the Mediterranean is to develop general common frameworks and guidelines that can be adapted to each country's specific context.

In recent years, the rise in the number of landscape fires and the areas affected has garnered attention from states and government agencies, as well as individuals, private sector organizations and international institutions. The proximity of residential and industrial areas to forests, the construction of more houses in forested areas, tree planting around homes and settlements for various purposes – including recreation, protection from sunlight, and increased privacy – along with the greater number of tree-lined parks in cities and similar developments, have contributed to the increased visibility of wildfires. Governance plays a key role in international and regional collaboration, and it is essential for countries to share existing good practices and reference documents.

The historical and ongoing collaboration in landscape fire management within the Mediterranean region is closely linked with international efforts and regional initiatives that either border or fully encompass the Mediterranean region. Over the past 5 years, international and regional collaboration has made progress in several strategic areas, both in the context of thematic conferences and various working groups.

Regional and international dialogue and exchange

Countries in the Mediterranean region are participating in regional and global thematic networks. The *Silva Mediterranea* Working Group on Forest Fires is one of 14 Regional Wildland Fire Networks, which are part of the Global Wildland Fire Network (GWFN),[16] established in 2001 by the Global Fire Monitoring Center (GFMC) under the auspices of the United Nations Office for Disaster Risk Reduction (UNDRR). The global network is currently supported by eight Regional Fire Monitoring Centers (RFMCs) and Regional Fire Management Resource Centers (RFMRCs).

In the European Union, EFFIS is supported by the Expert Group on Forest Fires (EGFF), which includes representatives from EU member states and NENA countries. The main role of the EGFF is to provide advice for the implementation and further development of EFFIS as well as recommendations for improving wildfire prevention in the European and Mediterranean regions. This successful regional initiative has recently been replicated in Latin America and the Caribbean under the leadership of the European Commission and with

[16] https://gfmc.online/globalnetworks/globalnet.html

support from Mediterranean countries, among others.

At the pan-European level, the Council of Europe, through the secretariat of the European and Mediterranean Major Hazards Agreement (EUR-OPA), has tasked the GFMC as a specialized centre with offering capacity building and regional cooperation in landscape fire management in its 47 member states. The first regional branch of GFMC, known as the RFMC is the coordinator of the Regional Southeast Europe / Caucasus Wildland Fire Network and was established by GFMC in 2010, with financial support from the Council of Europe.

Similarly, the Organization for Security and Cooperation in Europe (OSCE) has been addressing wildfire disaster risk reduction since 2006. OSCE member states, notably countries in Southeast Europe and the Near East, have participated in regional exchanges and training in fire management. In 2023, the OSCE programme "Strengthening Responses to Security Risks from Climate Change in South-Eastern Europe, Eastern Europe, the South Caucasus and Central Asia" conducted capacity building on cross-boundary cooperation in fire preparedness and response in four protected areas of Korab-Koritnik, Mavrovo, Shar Mountain and Sharri/Šara in North Macedonia, Albania and Kosovo (*UNSCR 1244 (1999)*, 1999).

As part of the agenda of the Ministerial Conference on the Protection of Forests in Europe (FOREST EUROPE), representatives of most of the 46 signatory states attended the workshop "Develop, Adopt and Transfer Innovative Solutions and Actions to Prevent and Control Wildfires," jointly organized by the General Directorate of Forestry of Türkiye, *Silva Mediterranea* and FOREST EUROPE on 24–27 October 2022, Antalya, Türkiye. One of the aims of FOREST EUROPE is the development of the Pan-European Forest Risk Facility (FoRISK).

In the context of Euro-Mediterranean cooperation, the Union for the Mediterranean (UfM) introduced the Mediterranean Framework on Civil Protection during the fourth meeting of civil protection directors general in October 2023. The UfM initiative aims to enhance solidarity in the Mediterranean region, building on the EU Civil Protection Mechanism.

Another important platform for international dialogue in the region is the Near East Network on Wildlands Forest Fire (NENFIRE), which is a subsidiary body of the Near East Forest and Range Commission (FAO). The NENFIRE consists of 20 NENA countries, hence including several countries from the Mediterranean. The main objectives of the network are to strengthen collaboration in the region and to share knowledge in fire management.

International investment banks like the World Bank are putting more emphasis on landscape fires, by allocating more financial resources and providing technical expertise. For example, after the most devastating wildfire in Turkish history, in 2021, the World Bank started the Türkiye Climate Resilient Forests Project to strengthen institutional capacity for integrated fire management and increase the resilience of forests and people to wildfires in targeted areas of Türkiye, allowing a prompt and effective response in the event of an eligible crisis or emergency.

The science–policy interface

The Regional Wildland Fire Networks, notably the RFMCs, are supporting countries and regional organizations to develop national and regional landscape fire management policies by strengthening the science–policy interface. For example, in the EM region, the Landscape Fire Management in the Western Balkans (LFMWB) programme, aims to establish strong and fully operational national and regional networks for landscape fire management. It seeks to initiate multistakeholder policy dialogues, foster better cooperation, and strengthen governance and institutional capacities in this field.

As part of EU-funded programmes, several research projects, such as FIRE-ADAPT, FIRE-RES, FirEUrisk and Firelog, which focus on integrated wildfire management, are bridging the gaps between science, practitioners and end users. Mediterranean countries are involved in most of these projects, sharing their knowledge and expertise, and providing pilot areas. A multisectoral approach and the integration of end users from the beginning of projects are significant steps forward in achieving the project objectives and maximizing investments.

Preparedness and response to wildfire emergencies

Over the past 5 years, the EuroFire competency standards and training materials have been made available in 22 languages, including eight language versions for the 28 member countries of *Silva Mediterranea*.

The EU Civil Protection Mechanism is a key mechanism among the 27 EU countries and ten participating states – Albania, Bosnia and Herzegovina, Iceland, Montenegro, North Macedonia, Norway, Republic of Moldova, Serbia, Türkiye and Ukraine. Its aim is to strengthen cooperation in civil protection and to improve prevention, preparedness and response to disasters. Mediterranean countries actively participate in activating the EU Civil Protection Mechanism and providing assistance to other countries too. The peer review programme and advisory missions launched by the EU Civil Protection Mechanism have grown in recent years, with a particular focus on wildfires, and with several Mediterranean countries participating and benefiting from this programme.

Development of a coordinated international cooperation strategy and mechanism

The ongoing collaboration between FAO and the United Nations Environment Programme (UNEP) has led to the planning and development of a Global Fire Management Hub ("the Fire Hub"). Announced at the XV World Forestry Congress and welcomed by FAO Member Nations during the 26th Session of the Committee on Forestry (COFO),[17] the Fire Hub was officially launched at the eighth International Wildland Fire Conference (IWFC) in May 2023. Its goal is to strengthen the capacities of countries to implement integrated fire management in order to reduce the negative impacts of wildfires on livelihoods, landscapes and the global climate. In 2023 and 2024, FAO convened a series of technical workshops and consultations, in collaboration with UNEP, UNDRR and the World Meteorological Organization (WMO), to bring together key partners of the Fire Hub and define its governance and operationalization. These discussions included integrating 25 years of experience from the GFMC into the Fire Hub and connecting it to the Global Wildland Fire Network of GFMC and its associated regional networks and centres. The *Silva Mediterranea* Working Group on Forest Fires, representing the Regional Mediterranean Wildland Fire Network, is also involved in the integration process.

Furthermore, the Landscape Fire Governance Framework,[18] the development of which was led by Portugal, was presented at the eighth IWFC. The guidelines provided in the framework complement the FAO Integrated Fire Management Voluntary Guidelines (FAO, 2024) and should be allowed to guide the development of national, regional and international landscape fire management policies. During the 19th Session of the United Nations Forum on Forests (UNFF), the importance of the framework for holistic integrated fire management planning was acknowledged as an effective approach.

At the regional level, other reference documents have been launched in recent years, taking into consideration the Mediterranean reality with regard to landscape fires and supporting the regional approach to wildfire prevention, such as:

- **Land-based wildfire prevention paper** (DG ENV, 2021): *Land-based wildfire prevention: principles and experiences on managing landscapes, forests and woodlands for safety and resilience in Europe*.
- **Key recommendations on wildfire prevention in the Mediterranean** (Mauri *et al.*, 2023): Specific actions for each recommendation identified as necessary to improve fire prevention and reduce risk.

[17] https://www.fao.org/3/nk728en/nk728en.pdf (paragraph 20)

[18] https://www.wildfire2023.pt/conference/framework

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Chapter 6 - The role of urban and peri-urban forests in improving sustainability at the urban–rural interface

Simone Borelli,[1] Michela Conigliaro,[1] Federica Di Cagno,[1] Fabio Salbitano,[2] Paloma Cariñanos,[3] Sondes Fkiri,[4] Urša Vilhar,[5] Giovanni Sanesi,[6] Pierre Sicard,[7] Pedro Calaza,[8] Erdoğan Atmış,[9] Sara Di Lonardo,[10] Dimitris Tsimplinas[11]

[1] Food and Agriculture Organization of the United Nations, Rome, Italy

[2] University of Sassari, Italy

[3] University of Granada, Spain

[4] National Research Institute of Rural Engineering, Water and Forests, Tunisia

[5] Slovenian Forestry Institute, Slovenia

[6] University of Bari, Italy

[7] ACRI-ST, France

[8] Spanish Association of Public Parks and Gardens (AEPJP), Spain

[9] Institute for Environmental Studies (IVM), Vrije Universiteit Amsterdam, Kingdom of the Netherlands

[10] Research Institute on Terrestrial Ecosystems (IRET), National Research Council (CNR), Sesto Fiorentino, Italy

[11] Ministry of Environment, Energy and Climate Change, Greece

Introduction

The urban population of the Mediterranean was approximately 562 million in 2020, and it is projected to rise to 669 million by 2050 (UNDESA, Population Division, 2018).

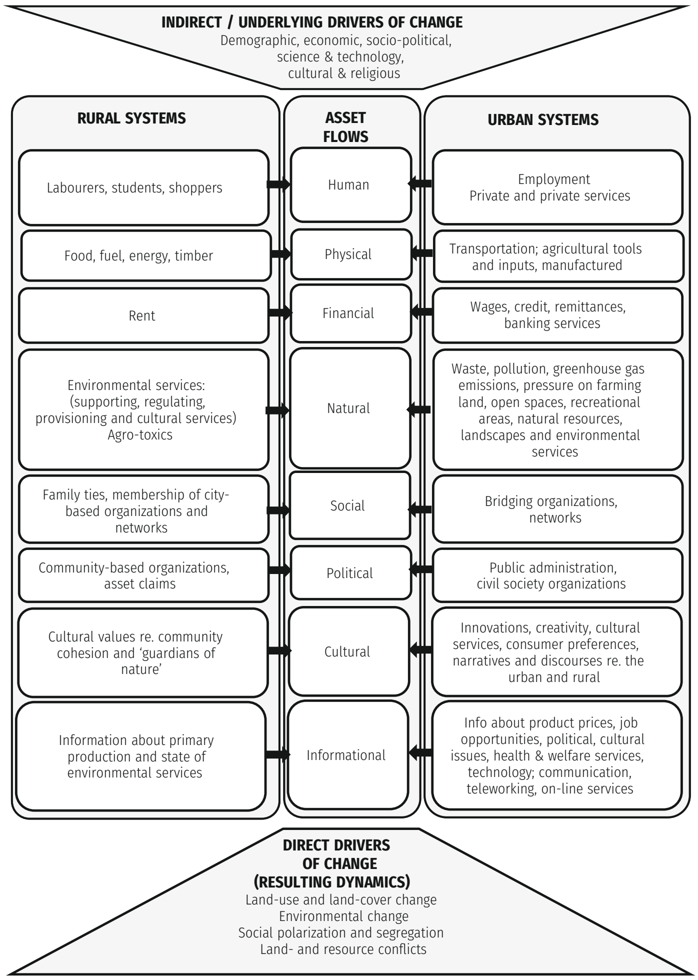
As cities grow, so does their demand for resources, such as food, water and energy, putting huge pressure on peri-urban and rural areas where these resources are produced. This urban expansion often results in a one-way flow of ecosystem goods and services as cities progressively drain rural reservoirs without replenishing them, thereby disrupting ecological balances and reducing the benefits that these ecosystems provide.

At a time when balancing rural areas and urban sprawl is critical, understanding the underlying dynamics of urban–rural exchanges is of utmost importance. These exchanges between urban and rural areas form the foundation for providing essential goods – such as food, water, timber, fibre and energy – known as provisioning ecosystem services, along with many other ecosystem services that provide regulating, supporting and cultural benefits. At the core of this balance is the concept of ecosystem connectivity (Staccione, Candiago and Mysiak, 2022), which entails creating channels for ecosystem services that go beyond municipal boundaries. This approach helps tackle landscape fragmentation and the resulting degradation of ecosystems, while also improving the urban ecosystem itself.

Historically, Mediterranean cities were compact, but the rapid urbanization that began in the twentieth century has since shifted towards more expansive urban development because of rural-to-urban migration coupled with the displacement of urban residents caused by the gentrification of city centres. This has led to serious social challenges and the fragmentation of natural landscapes, which threatens biodiversity and weakens ecological connectivity. By 2030, the Mediterranean region is projected to become one of the biodiversity hot spots with the highest urban cover, which is set to increase by 160 percent. This increase is second only to that experienced by the Eastern Afromontane region, which is expected to see a 1 900 percent rise in urban cover (Seto, Güneralp and Hutyra, 2012).

Since the mid-twentieth century, rapid urban development has transformed natural and semi-natural habitats and led to a dramatic increase in substrate impermeability. Soil sealing is considered one of the main causes of land degradation in Europe (Ferreira *et al.*, 2022), with particular reference to the urban–rural interface (URI). Critical land cover transformation in peri-urban areas has had detrimental effects on both the urban and rural environments, amplifying the impacts of climate change.

Figure 6.1. Asset flows at the urban–rural interface



Note: As cited in Ros-Tonen, Pouw and Bavinck (2015): flows and direct drivers are adapted from Douglass and from Allen; the flows have been restructured as asset flows, considering Castells' concept of "space of flows"; and indirect drivers and environmental services are based on the Millenium Ecosystem Assessment.

Source: Ros-Tonen, M., Pouw, N. & Bavinck, M. 2015. Governing Beyond Cities: The Urban-Rural Interface. In: J. Gupta, K. Pfeffer, H. Verrest & M. Ros-Tonen, eds. *Geographies of Urban Governance: Advanced Theories, Methods and Practices*. pp. 85–105. Cham, Switzerland Springer International Publishing. https://doi.org/10.1007/978-3-319-21272-2_

The URI is the transitional zone where urban and rural areas converge. It is characterized by rapid land-use changes and significant demographic shifts. It is more than just a physical boundary; it is a dynamic space where the influences of urban and rural environments intermingle, creating both challenges and opportunities in ecological, social and economic terms. In many peri-urban areas, inadequate living conditions expose residents to climate-related risks, such as floods and droughts (IPCC, 2014). Furthermore, air pollution and heat waves disproportionately affect Mediterranean cities compared to northern Europe, posing significant public health challenges, especially among vulnerable populations (Ballester *et al.*, 2023; Neira *et al.*, 2023; Rodríguez *et al.*, 2007).

Although cities provide rural areas with intangible benefits such as financial flows, technological advancements and cultural innovation, these advantages do not make up for the depletion of natural resources and ecosystem services (Ros-Tonen, Pouw and Bavinck, 2015). The URI thus becomes a spatial entity in its own right – a zone of unequal exchange, where the flows of ecosystem services are unbalanced. Addressing these imbalances at the URI is crucial, as they directly affect the reciprocity and equitable exchange between rural and urban areas. Achieving this requires integrated urban planning strategies that prioritize land management, resilience building, and equitable access to resources and services.

In this context, peri-urban forests[19] can greatly help re-balance an uneven distribution and flow of ecosystem goods and services along the URIs of the Mediterranean region. As shared assets, these forests can connect urban and rural environments, providing mutual benefits to both populations at the same time. This chapter explores the specificities of the Mediterranean URI; the role that peri-urban forests play in balancing the flows of products and services between rural and urban areas; and the importance of recognizing the URI as a specific spatial type that requires distinct strategies in respect of the planning and management of peri-urban forests.

Specificities of the urban–rural interface and the role of urban and peri-urban forests

Ecological and environmental specificities of the urban–rural interface

From an ecological perspective, the URI features a diverse range of habitats, including remnants of natural vegetation, agricultural land, urban greenspace, and newly established woodlands in abandoned sites and brownfields (Trentanovi *et al.*, 2021). This diversity supports a variety of species and ecological processes, making these areas crucial for biodiversity conservation and food production. As we will see in the examples below, by regulating ecosystem processes and the flow of goods and services between urban and rural areas, peri-urban forests and trees play a pivotal role in mitigating the impacts of urban sprawl and land conversion, boosting resilience to disasters and climate change effects, and improving the overall quality of urban and peri-urban environments.

The URI is particularly susceptible to land-use change, driven by the expansion of urban areas, and its ecological integrity is often compromised by habitat fragmentation. The conversion of land from rural to urban uses often leads to significant environmental impacts, including soil degradation, loss of biodiversity, and alterations to the hydrological cycle. Healthy and diverse peri-urban forests can play a key role in mitigating these ecological disruptions. A notable example of this can be found in Ljubljana, Slovenia, where data were collected to estimate the reduction of surface runoff resulting from planting trees in a car park. The results show that pine trees could reduce surface runoff by 7.3 percent per year, while birch trees may provide a 4.8 percent reduction (Zabret and Šraj, 2019). Peri-urban forests can slow down rainwater runoff, recharge groundwater and increase water availability in soils, which is essential for soil health and resilience on peri-urban agricultural land.

Forests and trees serve as green corridors that connect fragmented landscapes and help conserve biodiversity, allowing for the movement of species and maintaining the balance of ecological processes. The 400 hectares of green belt surrounding Ouarzazate, Morocco, have acted as a buffer against desertification. This has helped reduce soil degradation and has protected the city from the strong winds and dust clouds that affect the area (UNEP, 2015). In Ljubljana, Slovenia, a mosaic of numerous forest remnants combined with larger forest complexes, helps maintain ecological connectivity, providing habitats for a variety of bird species and preserving the stability of their populations along the rural–urban continuum (de Groot *et al.*, 2021).

Urban and peri-urban forests also improve local climate resilience by sequestering carbon and regulating urban microclimates. Areas of the URI where vegetation consists of large woody species have the potential to serve as substantial carbon sinks. Research conducted in Rimini, Italy, showed that mature specimens of large species

[19] Networks or systems comprising all woodlands, groups of trees and individual trees located in peri-urban areas, including trees and woodlands in the URI (FAO, 2016).

such as *Platanus x acerifolia* can remove up to 9 kilograms (kg) of carbon dioxide (CO_2) from the atmosphere per day through photosynthesis, 65 years after being planted, and can sequester up to 220 kg CO_2 per year as new woody biomass, ultimately storing up to 7 tonnes of CO_2 in their overall woody biomass (Fini *et al.*, 2023). Studies using the life cycle assessment approach have highlighted how peri-urban forests are the option with the greatest potential as CO_2 sinks, considering both the above-ground vegetation and the soil (Nicese *et al.*, 2021).

The maintenance of healthy vegetation along the URI can also help minimize the risks associated with wildfire (Bento-Gonçalves and Vieira, 2020; Taccaliti *et al.*, 2023). In Italy, over 50 percent of forest fires occur within 300 metres of an urban area, highlighting the challenges at the wildland–urban interface (Mancini *et al.*, 2018). Furthermore, these areas are susceptible to experiencing recurring fire events at short intervals (Elia *et al.*, 2019). In Türkiye, cities have grown outwards, and for the past 60 years, settlements have gradually encroached on the forests around them. This urban sprawl has heightened the risk of forest fires, which have caused considerable damage to both the urban settlements and the forests. Additionally, the preparedness of forestry management and local governments has often been inadequate, leading to substantial losses of life and property during the fires (Şen, Güngör and Şevik, 2018). The Iberian Peninsula is one of the regions in the Mediterranean basin most susceptible to fires. This has led to the implementation of national plans for protection against fire and committees to fight forest fires in both Spain and Portugal. These strategies set out specific action plans to prevent fires in the URI, given that this area has experienced the highest increase in risk in recent years due to urban expansion and the abandonment of agricultural land. The progressive replacement of highly flammable non-native tree species, such as *Eucalyptus* spp., is one of the actions planned.

Finally, in some Mediterranean cities, woody perennial food-producing species have been used to establish urban food forests. This practice relies on a combination of agriculture, forestry and agroforestry in urban areas, and supplies cities with nutritious food while also improving urban biodiversity and enhancing social cohesion (Salbitano *et al.*, 2019). A notable example of a food forest is the Forest Vegetable Garden in Parco Nord, Milan, Italy. There, 2 000 fruit trees along with a variety of vegetables and herbs have been planted together in a way that mimics natural ecosystems, providing fruit such as berries that are edible for humans and for the local wildlife. The project aims to grow food while simultaneously enhancing biodiversity. In doing so, the Forest Vegetable Garden helps establish green corridors that connect fragmented habitats around the edges of the city, benefiting both biodiversity and the people living there.

Social specificities of the urban–rural interface and the role of urban and peri-urban forests in social integration and community building

The URI is often characterized by population changes, as urban residents seek a more rural lifestyle and rural inhabitants move closer to urban centres in search of economic opportunities. This creates a hybrid social environment, where rural traditions and urban lifestyles intersect.

However, the URI is shaped not only by demographic shifts between urban and rural populations, but also by global migration patterns. In Mediterranean cities, lower-income populations and migrants often reside in suburbs or on the outskirts of urban centres where housing is more affordable, and employment opportunities are more accessible to them. While this can foster cultural exchange and social integration, it can also create challenges related to social cohesion and community identity, particularly if the needs and values of different groups are not adequately addressed.

A prime example of improving social integration through peri-urban forests can be seen in Catalonia, Spain. The Parc Natural de Collserola, a peri-urban park located west of Barcelona, serves as a cultural venue and natural site for residents from diverse neighbourhoods and backgrounds. By hosting cultural and educational events and providing a place for recreation, the Parc Natural de Collserola offers a shared space to urban and suburban residents, fostering social interaction and integration. The Taza National Park in Algeria is another example of successful collaboration between urban and rural areas. It offers residents a shared recreational area to enjoy nature and take part in activities that promote environmental awareness (Bouchentouf, 2019; Moulaï, 2020).

However, social dynamics can be further complicated by the emergence of informal settlements or slums, which frequently develop in the suburbs of cities, typically occurring in areas where the lack of affordable housing fails to meet the needs of growing populations, particularly among low-income groups, including migrants. The existence of slums within the URI can exacerbate existing social inequalities, making it more difficult for residents to integrate into both urban and rural communities. A particularly relevant example of how peri-urban forestry can address these challenges is the recent dismantling of the Lombroso slum in Rome, which existed on the city's outskirts for 37 years. This marked a significant step towards fostering social inclusion and creating a healthier urban environment. The city implemented a relocation plan for 33 families, totalling 145 individuals, to provide new housing opportunities as well as integration programmes and tailored educational pathways for children. What makes this case especially noteworthy from the perspective of peri-urban forestry is the transformation of the former slum into a new urban forest. The site will be reforested with 145 trees symbolizing the relocated individuals, and the new green area will create a green corridor that connects to the nearby Santa Maria della Pietà park. By transforming a previously marginalized site into public greenspace, this initiative provides an opportunity to rebuild social ties while enabling social reconciliation after years of social fragmentation. Moreover, it balances upholding human rights through the provision of decent housing and social services, and restoring legality, urban decorum and environmental health.

Building on these exemplary initiatives, forests can also play a key role in addressing the broader disparities between urban and rural areas, particularly in terms of access to services and infrastructure. While urban residents typically have better access to health care, education, transport and other essential services, those living on the outskirts at the URI may face significant barriers. Forests and trees can help bridge these gaps by improving both the aesthetics and the functionality of peri-urban areas. The development of green corridors not only makes these areas more pleasant but also promotes more sustainable mobility options. By incorporating cycling paths into green areas, cities can create accessible, safe and environmentally friendly alternatives for commuting and recreation, which can also help reduce traffic congestion and pollution both at the URI and within urban centres. A successful example of this approach can be found in Marseille, France, with the ambitious rehabilitation programme of the Longchamp park. This initiative aimed to restore this historic park and make it more accessible and appealing to all residents, particularly by reducing environmental disparities between the affluent and less privileged neighbourhoods in the city. The initiative is part of a broader citywide effort to promote sustainable mobility. Marseille is actively developing green paths and cycle lanes to connect its peripheral neighbourhoods, such as the 1.7 kilometre-long green path that links the Roy d'Espagne pine forest to the sea at Pointe Rouge, featuring both pedestrian walkways and cycling paths.

In both Rome and Marseille, peri-urban forestry initiatives highlight how green infrastructure can help bridge social divides and enhance environmental sustainability. These projects not only improve the quality of life for residents living on the URI but also contribute to broader social and environmental goals, demonstrating the essential role of peri-urban forests in building inclusive and resilient communities. Moreover, they show that addressing social disparities at the URI requires targeted investments in infrastructure and services that cater to the diverse needs of both urban and suburban communities, ensuring that the benefits of urbanization are shared more equitably across the interface zone.

Tree house in the peri-urban forest of Celje, Slovenia.

Economic specificities of the urban–rural interface and the role of urban and peri-urban forests in improving livelihoods

The URI features a diverse economic landscape, where agricultural and non-agricultural activities co-exist. Agriculture remains a significant economic activity in many interface areas in the Mediterranean region, providing livelihoods for rural populations and contributing to the food security of nearby urban centres. At the same time, the proximity to urban markets creates opportunities for diversifying economic activities, including various industries, such as manufacturing, tourism and service-oriented businesses. Economic diversification can strengthen the resilience of interface communities, allowing them to adapt to changing economic conditions and reducing their reliance on any single source of income.

However, land values in the URI are often highly variable, reflecting the competing demands for land in these areas. As urban areas expand, the value of land in the interface zone tends to increase, due to speculation and the potential for future development. This can lead to economic displacement. The changes in land ownership patterns can have significant social and economic consequences, including the loss of agricultural land, disruption of rural livelihoods, and the transformation of the interface areas into more urbanized environments. In such contexts, urban and peri-urban forests can offer a valuable buffer by supporting economic activities and ecosystem services that contribute to the local economy. Sustainable management of urban and peri-urban forests can generate income through ecotourism, agroforestry, and the sale of forest products, creating jobs for local communities while promoting environmental conservation. The peri-urban forest of Celje, Slovenia, is an excellent example of a sustainably managed forest area on the fringe of a city, designed for ecotourism and providing a stimulating and diverse outdoor environment.

Other initiatives aimed at conserving and restoring peri-urban forests focus on the preservation of agricultural areas. In the peri-urban environment known as La Vega, in Granada, Spain, irrigated agriculture for crops like potatoes, tobacco and corn, is being replaced by the revival of dryland crops, including wheat, barley and legumes, the sustainable use of traditional *choperas* – forest formations of various *Populus* species, and farm parks and alternative food networks. These alternative management practices are allowing peri-urban farmers to sustain their businesses and lifestyles, thereby reinforcing their resilience within an urban environment.

The employment landscape at the URI is characterized by a mix of formal and informal economies. In addition to traditional agricultural work, residents may also find employment in nearby urban centres, start small-scale businesses, or participate in the informal economy. This flexibility can be both an asset and a challenge, as it allows residents to adapt to changing economic conditions but also exposes them to vulnerabilities, such as job insecurity and a lack of social protection. Taking Spain as a reference, the OECD (2024) estimated that URIs have the potential to create approximately 2.5 million green jobs over the next 10 years, which would increase the proportion of the total population employed in the green job sector from the current 1.75 percent to 10 percent. These jobs are expected to be concentrated in sectors linked to environmental policies and urban afforestation at different scales. One of the most important areas where green jobs will be created is in the management and maintenance of urban and peri-urban forests. These economic activities not only provide direct employment but also boost related industries within the sector. Understanding the employment dynamics in the interface zone is crucial for developing policies that support sustainable livelihoods and reduce economic inequality.

Peri-urban forests can provide alternative sources of local construction materials, contributing to strengthening the wood value chain, including from a circular bioeconomy perspective. This reduces the pressure on natural forests from urban areas and increases the sustainability of both energy sources and wood flows from rural to urban areas.

Urban and peri-urban forests and trees also provide indirect economic benefits both in urban and rural areas. By shading and screening buildings, urban forests and trees help save money on cooling and heating; they contribute to improved public health (WHO Regional Office for Europe, 2016; Wolf *et al.*, 2020), which reduces health care costs (Donovan, 2017; McDonald *et al.*, 2017; Wolf *et al.*, 2015; Wolf and Robbins, 2015). The contribution of greenspace to health was measured by the reduction in costs associated with major cardiovascular and respiratory diseases, including mortality and hospital admissions. This assessment encompassed health care expenses, lost productivity among workers and welfare losses, such as the costs incurred from hospital admissions. Peri-urban forests improve mental health and provide space for physical activities, helping offset the increase in non-communicable diseases linked to a sedentary and inactive lifestyle. There are many examples in the Mediterranean region that highlight efforts to strengthen the role of urban and peri-urban forests as key promoters of urban health. A recent longitudinal study conducted on 600 000 residents of Rome over a 10-year period has highlighted the positive effect of urban forests on mental health. Residents who live near trees require fewer medical prescriptions for psychotropic drugs (Spano *et al.*, 2023). The "Breathing in the Parks" initiative promoted by the *Silva Mediterranea* Working Group on Urban and Peri-urban Forests and led by scientists from the University of Granada, Spain, illustrates how the health impacts of allergens released by urban forests can be reduced. Measures such as increasing specific and functional biodiversity, controlling the introduction and spread of exotic and invasive species, promoting gender equality, and understanding the allergenic potential of each tree species are essential for designing healthy green spaces (Cariñanos *et al.*, 2019).

Increasing the availability of quality peri-urban forests and parks is also key in promoting the sustainable enjoyment of these spaces, as it would help distribute human-induced pressure across different natural spaces. In France, the people of Marseille often visit the nearby Calanques National Park to go hiking and climbing and enjoy the stunning coastal scenery. In Tunisia, residents of Tunis visit the region's forests, like the Boukornine Forest close by, for picnics, walks and a chance to enjoy nature.

Key aspects of governing the urban–rural interface as a distinct land type

Urban fringes have historically been viewed as transitional zones between urban and rural areas, but this perspective fails to recognize their unique characteristics and importance within the broader urban–rural continuum.[20] While the URI is a dynamic zone marked by the flow of people, goods and services – including ecosystem services – it also represents a physical space at the urban fringe "that is not rural but not yet urban", with distinct specificities and challenges (Lerner and Eakin, 2011). This calls for a tailored approach to planning, governance and management, especially to address the unequal flow of goods and services,

[20] The "urban-rural continuum" refers to the gradual transition and interdependence between urban and rural areas, a conceptual gradient across various degrees of urbanization and rural characteristics, rather than a clear-cut boundary between urban and rural areas. This continuum reflects the interconnectedness between urban and rural areas and the diverse functions they serve within regional landscapes and economies.

where urban areas typically extract natural resources from rural and peri-urban areas without providing a proportional return. Addressing this imbalance requires a paradigm shift in the way the URI is perceived, moving away from its conventional treatment as a buffer zone to recognizing it as an area in its own right.

In policy terms, the URI should be managed using a tailored approach that avoids both replicating urban governance models and applying rural management practices, requiring instead planning frameworks that consider its multifunctionality and address the need to balance urbanization with agricultural production, biodiversity conservation, and the provision of ecosystem services (Depietri and Orenstein, 2020; Doernberg and Weith, 2021). This is particularly relevant since urbanization continues to drive the expansion of cities into peri-urban areas, creating dynamics of "peri-urbanization" (López-Goyburu and García-Montero, 2018; Shaw, van Vliet and Verburg, 2020). The planning for the URI should consider it a multifunctional landscape that supports both urban and rural functions without compromising its environmental, social and economic specificities.

Urban forestry, and peri-urban forestry specifically, can play an important role in this process. These forests act as shared assets that improve the flow of ecosystem services between urban and rural areas, while also contributing to the peri-urban economy, such as by creating green jobs. In addition, they can provide green and recreational spaces that foster a stronger sense of place, enhance social cohesion, and improve the well-being of the diverse communities that inhabit the URI. The multifunctionality of peri-urban forests has the potential to trigger the transformation of the URI into an "opportunity space" (Scott *et al.*, 2013), where economic, environmental and social benefits are integrated and mutually reinforced, ultimately strengthening the integrity of the URI as an area in its own right.

To fully realize the potential of peri-urban forests, an important aspect is to recognize the social heterogeneity of URI inhabitants and address the challenges related to the URI's governance. The first step towards effective governance structures involves the recognition among urban planners, citizens and suburban residents that urban growth and peri-urban changes are interlinked, often resulting in land-use conflicts. The URI frequently extends across multiple administrative boundaries, with institutional fragmentation preventing the smooth resolution of these conflicts. Multilevel governance fragmentation can assist in overcoming this institutional and governance, and eventually strengthening the URI. This involves distributing authority both horizontally, among municipalities and local actors along the urban–rural continuum, and vertically, across different institutional levels of government, including the local, regional and national levels (Ros-Tonen, Pouw and Bavinck, 2015).

For instance, in many Mediterranean countries, national governments are responsible for broader planning and management of forested areas for environmental protection and resource use (OECD and UCLG, 2019), which includes peri-urban forests. However, a peri-urban forest may be owned by a national authority but managed by local authorities, which are better equipped to deal with issues such as facility maintenance, safety and community engagement. An example is the Montseny Natural Park in Spain,[21] which is located near Barcelona. This park is managed collaboratively by national conservation agencies,[22] the Regional Government of Catalonia, the two autonomous provinces of Barcelona and Girona, and four local municipalities. This multilevel governance system ensures that the park serves both local peri-urban recreational needs and national conservation goals.

Introducing the concept of multilevel governance acknowledges the complex administrative landscape of the URI and emphasizes the importance of involving multiple institutional stakeholders in the planning and management of peri-urban forests.

In conclusion, to manage the Mediterranean URI as a distinct dimension, it is essential to adopt a holistic, cross-sectoral and multilevel governance approach that integrates both urban and rural

[21] https://costabrava.org/en/what-to-do/nature/natural-parks/montseny-natural-park/#:~:text=The%20management%20plan%20for%20El%20Montseny%20Natural%20Park%2C,government%20offices%2C%20and%20groups%20associated%20with%20the%20region

[22] UNESCO and the Spanish Ministry for Ecological Transition and Demographic Challenge (MITECO).

development. By focusing on policies that address the unique characteristics of the URI and by leveraging the potential of peri-urban forests as multifunctional assets, cities in the Mediterranean can achieve more equitable and balanced exchanges between urban and rural areas, while strengthening the ecological and socioeconomic resilience of the peri-urban communities.

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Chapter 7

Advancing integrated assessments of the state of forests and forest-related trends in the Mediterranean

Dania Abdul Malak,[1] Ana Isabel Marín,[1,2] Antonio Sánchez,[1] Nassima Yahi,[3] Ouahid Zanndouche,[4] Lara Samaha,[5] George Mitri,[6] Daniel Moreno,[7] Patricia Adame,[7] Isabel Cañellas,[7] Iciar Alberdi,[7] Javier Chico,[8] Annemarie Bastrup-Birk[9]

[1] European Topic Centre on Spatial Analysis and Synthesis, University of Málaga, Spain

[2] Department of Geography, University of Málaga, Spain

[3] Department of Ecology and Environment, University of Sciences and Technology Houari Boumediene, Algeria

[4] Forest Ecosystem Sciences Division, National Forest Research Institute, Algeria

[5] Department of Ecosystems, Ministry of Environment, Lebanon

[6] Land and Natural Resources Programme, Institute of the Environment, University of Balamand, Lebanon

[7] Institute of Forest Science, National Institute for Agricultural Research and Technology (ICIFOR-INIA), Madrid, Spain

[8] Ministry for Ecological Transition and Demographic Challenge (MITECO), Madrid, Spain

[9] Forests and Environment, European Environmental Agency, Copenhagen, Denmark

Introduction

Integrated assessment approaches synthesize various data sources and promote evidence-based decision-making and stakeholder engagement (*EU Biodiversity Strategy for 2030*, 2020). Mapping the causal chain from driving forces to impacts and responses is a complex task as the various cause–effect relationships need careful description, and environmental changes can rarely be linked to a single cause. Many impacts are interconnected. For example, drought and fires can trigger pest and insect infestations in an ecosystem (Knutzen *et al.*, 2025; Seidl *et al.*, 2017). Therefore, understanding the primary drivers of change and quantifying their impacts is essential for integrated assessments of the state of forest ecosystems and related trends. Further, combining findings from multiple approaches provides stakeholders with a more holistic understanding of ecosystems, which is necessary for supporting effective conservation and management strategies (*EU Biodiversity Strategy for 2030*, 2020).

Investing in long-term monitoring programmes and collaborative efforts is crucial for designing integrated assessment approaches, safeguarding vital biodiversity, sustaining ecosystem services, and promoting sustainable forest management practices (Muys *et al.*, 2022). Timely access to updated and comparable forest data enables the identification of disturbances caused by climate change and pressures from human-induced factors, including rapid urbanization, agriculture and infrastructure development. This access to information is critical for assessing the ability of forests to withstand and recover from these disturbances (Vallecillo *et al.*, 2022). By tracking indicators, such as forest health and landscape connectivity, stakeholders can evaluate the effectiveness of management practices and implement adaptive management strategies as required (EEA, 2023). Further, policymakers can integrate forest information into land-use planning processes to balance conservation and sustainable development (*EU Biodiversity Strategy for 2030*, 2020).

The forests of the Mediterranean basin are mainly located in the northern (mesic) regions. In the drier southern areas, forests thrive only in locations where topography or altitude ensures enough water to support their growth (Peñuelas and Sardans, 2021). Mediterranean forests are well known for their rich biodiversity and the vital ecosystem services they provide (Nocentini, Travaglini and Muys, 2022). But they are facing many direct and indirect pressures, which increase their vulnerability to disturbances and lead to the degradation of ecosystem functioning.

Mediterranean forests are a prime example of ecosystems that require a comprehensive region-wide monitoring and integrated assessment approach. Recent literature indicates that global change impacts – such as increased droughts, overuse of natural resources, pest expansion, and fire and soil degradation – pose major and growing risks to these forest ecosystems (Gauquelin *et al.*, 2018). These impacts are synergistically driving quantifiable habitat degradation, loss of biodiversity, and forest decline and dieback in the region (Peñuelas and Sardans, 2021).

Although several studies have been conducted to advance our knowledge and test partial indicators of Mediterranean forest ecosystems in the region, they vary in terms of the methodologies used and the pressures and resulting impacts assessed. For example, the impact of tourism expansion on Mediterranean forests has been studied in Greece, where a direct correlation between tourist arrivals and forest degradation has been shown (Kolios, Ntogas and Zervas, 2020; Meyer *et al.*, 2020). Several other studies, including Appiagyei *et al.* (2023) and Ciobotaru, Patel and Pintilii (2021), have also assessed the pressure on forests in the Mediterranean region, by quantifying the loss of tree cover due to expanding urban areas and infrastructure development. A study by Camia, Libertà and San-Miguel-Ayanz (2016) projected future wildfire risk in Mediterranean forests under different climate scenarios, highlighting the need for adaptive management strategies to mitigate fire impacts. While these studies increase our understanding, our grasp of the state of forest ecosystems and related trends on a Mediterranean scale remains limited. Understanding and quantifying the impacts of climate change and other pressures on Mediterranean forests require modelling approaches that integrate biophysical and socioeconomic factors as well as harmonized region-wide indicators for assessing forest condition. There is an urgent need for the application of an integrated assessment approach to develop a baseline with harmonized indicators of forest condition and pressure at the regional scale, which could be used as a reference for evidence-based long-term planning and monitoring of forests in the region.

The studies mentioned above further highlight the crucial need for diverse data sources that encompass comprehensive forest information, statistics and maps related to Mediterranean forests (Marín *et al.*, 2021). This is essential for effectively understanding the current state and trends in these forests, quantifying their ecosystem services and supporting informed decision-making in land-use planning and policy development (*EU Biodiversity Strategy for 2030*, 2020). In addition, facilitating integrated ecosystem assessments, such as forest assessments, is critical for providing valuable information about the Mediterranean basin's capacity to support and ensure the well-being of its population (Balzan *et al.*, 2019).

This chapter explores innovative research-based approaches and integrated assessment techniques that can be applied at the basin level to enhance our understanding of Mediterranean forests and guide informed actions and decisions. It emphasizes the need for continuous monitoring, data sharing and evidence-based decision-making over time to minimize adverse impacts on these vital ecosystems. We further highlight the importance of establishing or identifying an existing body that can host, maintain and update such assessment results over time.

Integrated assessment approaches

Ecosystem assessments are evaluations conducted at different levels and in various formats to document the factors that affect the health and functioning of ecosystems. Initiated in 2001, the Millennium Ecosystem Assessment (MEA) used an innovative approach to assess the consequences of ecosystem change for human well-being, synthesizing the findings of existing research to provide a scientific basis for action (MEA, 2005). The MA's ecosystem assessment approach helped provide a more holistic understanding of biodiversity and ecosystems, including the policies, practices, technologies and behaviours that best lead to the effective conservation and sustainable use of biodiversity. Today, ecosystem assessments contribute to achieving set targets related to the Sustainable Development Goals, conservation and the climate.

In 2019, the Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services (IPBES) carried out a global integrated assessment that combined natural and social science perspectives, a range of knowledge systems, and multiple dimensions of value. This resulted in a more holistic assessment of indirect drivers as root causes of changes in nature, along with the associated risks to quality of life and people.

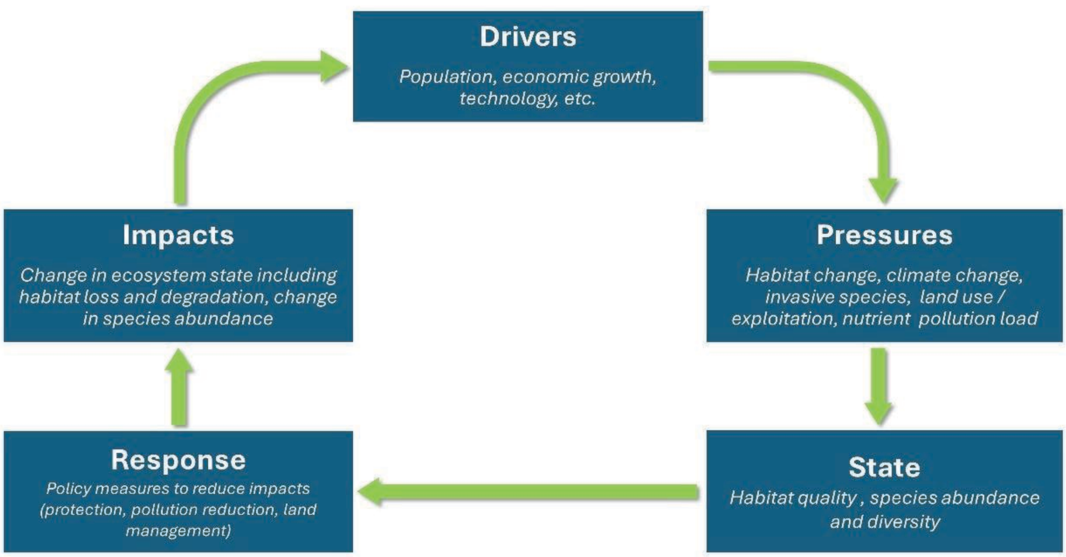
In line with the IPBES integrated ecosystem assessment approach, the EU Biodiversity Strategies for 2020 and 2030 emphasize the need for comprehensive mapping and assessment of ecosystems to ensure that they are healthy and deliver benefits to society through the provision of ecosystem services. The effective application of this integrated ecosystem assessment approach has provided evidence-based guidance for prioritizing policies and actions in Europe (Maes et al., 2020).

A causal framework for integrated assessments

At the European level, the Drivers, Pressures, State, Impact and Response (DPSIR) assessment framework has been widely adopted by the European Environment Agency (EEA) as a tool for conducting integrated environmental assessments (EEA, 1998). It has been used since 1995 as part of the EEA's integrated approach for producing its reports on the state of the environment and state of nature in Europe (EEA, 2020).

The DPSIR framework provides a structured approach to understanding the interactions between human activities and the environment (Figure 7.1). It helps understand the cause-and-effect relationships between human actions and the effects they produce on the environment. For example, drivers like increased consumption create pressures such as pollution and habitat

Figure 7.1. The DPSIR framework for conducting European ecosystem assessments



Source: Adapted from Turner, R.K., Morse-Jones, S. & Fisher, B. 2010. Ecosystem valuation: a sequential decision support system and quality assessment issues. *Annals of the New York Academy of Sciences*, 1185: 79–101. https://doi.org/10.1111/j.1749-6632.2009.05280.x loss, which in turn affect the health of ecosystems and their ability to provide essential services for human well-being.

This causal framework has provided the foundation for many integrated assessments conducted in the region over the past decades.

In the Mediterranean region, **drivers** typically encompass various socioeconomic factors as well as urbanization, agricultural expansion, unsustainable land practices and climate change, while **pressures** refer to the activities or processes resulting from these drivers, that directly affect forest ecosystems. Examples of pressures include habitat loss, degradation, fragmentation, overexploitation, invasive species and diseases, all of which pose severe threats to biodiversity and ecosystem services. The **state** reflects the condition of forest ecosystems at a specific time. Mediterranean forests exhibit reduced biodiversity, habitat fragmentation, diminished carbon sequestration, and increased vulnerability to wildfires, erosion and water scarcity. **Impacts** are the consequences of pressures on forest ecosystems, ranging from loss of biodiversity, increased wildfires, soil erosion and water runoff, which adversely affect ecosystem resilience and downstream water quality and availability. Finally, the **response** to the challenges faced by Mediterranean forests include policy measures, management practices and community initiatives aimed at enhancing forest resilience.

Examples of actions taken at the EU level in response to changes in the condition of forest ecosystems include prescribed burning, reforestation programmes and land-use planning. Guided by the findings from integrated forest assessments conducted across Europe, the European Union has implemented various policies and regulations to address these challenges. The EU Timber Regulation (*EU Timber Regulation*, 2010) aimed to ensure the legality of timber products imported into the European Union, including those from the Mediterranean region. The Regulation on Deforestation-Free Products (*EU Regulation on Deforestation-Free Products*, 2023) replaces the EU Timber Regulation and further enhances efforts to combat deforestation.

The EU Biodiversity Strategy for 2030 (*EU Biodiversity Strategy for 2030*, 2020) emphasizes the importance of restoring degraded ecosystems like Mediterranean forests to improve their resilience. Additionally, the EU Forest Strategy for 2030 (*EU Forest Strategy for 2030*, 2021) promotes sustainable forest management practices and addresses specific challenges faced by Mediterranean forests, such as wildfires and water scarcity. These policies outline response actions that are crucial for protecting, restoring and sustainably using forest ecosystems in the Mediterranean region. The DPSIR's evidence-based approach (see Figure 7.1) ensures that responses are adaptive and address ongoing trends identified in a timely and focused manner, allowing for priority corrective actions to be implemented as needed.

Mapping and assessment of ecosystems and their services

Building on the DPSIR framework, the Mapping and Assessment of Ecosystems and their Services (MAES) initiative was launched in Europe to implement Action 5 of the EU Biodiversity Strategy to 2020 (Maes *et al.*, 2020). The MAES initiative was established as a collaboration between the European Commission, the EEA, its European Topic Centres and the EU member states.

This initiative identified concepts that link biodiversity to people, as well as methods, including standards and indicators, and the main sources of the data needed to map and assess the dominant ecosystems at the European scale, including those related to forests (EEA, 2015).

The MAES approach involved several key steps:

1. Conducting a comprehensive evaluation of existing data and formulating a practical methodology.
2. Developing a framework that connects ecosystems, biodiversity and human well-being by exploring drivers of change and their effects on ecosystem services.
3. Developing a standardized approach for conducting ecosystem assessments.
4. Developing a classification of ecosystems, pressures, ecosystem states and ecosystem services to enable consistency across evaluations.

Table 7.1. Key forest pressure and forest state trends, assessed for 2000–2018

	Key pressure/condition attribute	Indicator examples	Evidenced impact
Key pressure group	Habitat conversion and degradation (land conversion)	Forest cover change (net change) Tree cover loss Forest fragmentation (average forest area density)	Mixed trends. Stable forest cover change and forest fragmentation, positive forest land take, negative tree cover loss but significant lasting effects from historical degradation.
	Climate change impacts	Fires – burnt area Number of fires Effective rainfall (annual)	Almost exclusively negative short- and long-term trends. Some uncertainties about trends for key indicators.
	Pollution and nutrient enrichment	Tropospheric ozone (AOT40) Exceedances of critical loads for acidification	Positive trends for all three key indicators (ozone, acidification and nutrients) but exceedance of critical loads in a significant share of forests.
	Overharvesting	Ratio of annual fellings to annual increment	Unresolved short-term trends and stable long-term trends.
	Invasive alien species	Pressure by invasive alien species	Poor data availability.
	Other pressures	Forest pests, parasite and insect infestations Soil erosion	Poor data availability.
Key state/condition group	Structural ecosystem attributes (general)	Deadwood Landscape mosaic (index) Biomass volume (growing stock) Forest area	Positive long-term trend for most of the indicators (e.g. deadwood and growing stock) except for defoliation, which showed significant degradation.
	Structural ecosystem attributes based on species diversity and abundance (abundance of common forest birds)	Abundance of common forest birds	Positive short-term trend and stable long-term trend.
	Structural ecosystem attributes monitored under the EU Nature Directives and national legislation	Forests covered by Natura 2000 Share of forest habitats listed under Annex 1 of the Habitats Directive in favourable conservation status	Depending on the indicator, mixed trends were found. Long-term trend could not be assessed due to lack of data.
	Soil attributes (soil organic carbon and nutrients availability)	Soil organic carbon in forests Nutrient availability	Poor data availability.
	Functional attributes (e.g. land productivity dynamics and dry matter productivity)	Dry matter productivity Evapotranspiration Land Productivity Dynamics (NDVI)	Positive long-term trend for most of the indicators.

Source: Maes, J., Teller, A., Erhard, M., Condé, S., Vallecillo, S., Barredo, J.I., Paracchini, M.L. *et al.* 2020. *Mapping and assessment of ecosystems and their services: an EU wide ecosystem assessment in support of the EU biodiversity strategy*. Luxembourg, Publications Office of the European Union. https://data.europa.eu/doi/10.2760/757183

5. Identifying relevant indicators across various ecosystem types to assess states, services and pressures effectively.
6. Analysing baseline, short-term and long-term trends using a uniform statistical methodology while accounting for data uncertainty.

MAES data and indicators used in the forest ecosystem assessment

This ecosystem assessment implemented across the European Union included indicators related to forest area and forest area change from 2000 to 2018, in addition to 20 indicators on the major pressures facing forests and 15 others on forest state, covering a similar time frame (Maes *et al.*, 2020). It examined forest pressure and state trends (see Table 7.1) as well as the key drivers of degradation and potential options for improvement. The results, summarized in Table 7.1, highlight the relevance and sensitivity of the selected indicators in detecting changes over time. The assessment covered part of the Mediterranean region, focusing on EU countries only, and was used, together with the data infrastructure developed for European forests and forestry, namely the Forest Information System for Europe (FISE), as a basis for guiding efforts to develop an integrated assessment of forest ecosystems at the Mediterranean scale.

However, the implementation of the assessment faced several challenges, including gaps in data for certain regions and ecosystems, and inconsistent use of forest classifications (EEA, 2016; Maes *et al.*, 2020). For example, the biodiversity data collected were insufficient, and the soil indicators were limited. Among the assessment's shortcomings, the lack of short-term data was also an issue. It was therefore recommended to monitor forest cover change over shorter periods of less than 8 years, in order to better differentiate between the impacts of natural and human disturbances (Maes *et al.*, 2020).

Forest assessments in the Mediterranean

Monitoring the temporal and spatial evolution of transboundary Mediterranean forests, including their health aspects, can be a complex task due to their unique characteristics and the varying national systems used for mapping forests in the Mediterranean basin.

Management and policy responses that are informed by scientific evidence, such as ecosystem assessments, allow for a more thorough exploration of scenarios and management options (Maes and Jacobs, 2017). Despite efforts to implement regional ecosystem assessments over the past decade, studies have focused on specific parts of the Mediterranean basin. For example, certain areas have been included in regional assessments for Europe, Africa and Asia conducted by the IPBES, and in the European Union's MAES for EU countries. Ecosystem assessments of forests around the Mediterranean basin have typically been carried out at the local and national scale (Martín-López *et al.*, 2016).

The establishment of a comprehensive monitoring and integrated assessment approach for the entire Mediterranean region has been hindered by the lack of available and accessible empirical data at relevant spatiotemporal scales. That being said, some steps have been taken that serve as important building blocks.

An adapted DPSIR conceptual framework for the Mediterranean basin is now available. This framework takes into account the dynamic nature of Mediterranean socioecological systems, and can be used to inform evidence-based management practices (Balzan *et al.*, 2019).

The condition of a forest is generally assessed by conducting ground-level inventories to gather forest information, often supplemented by remote sensing surveys (Liang and Gamarra, 2020). Furthermore, the use of emerging technologies such as artificial intelligence (AI) combined with *in situ* data, opens up new opportunities for improved assessments of forest condition at both temporal and spatial levels.

National forest inventories

In many European countries, national forest inventories (NFIs) are key sources of information about forests, and are used to provide regular reports that meet both national and international needs for forest-related information (Tomppo *et al.*, 2010; Vidal *et al.*, 2016). National forest inventories assess many variables using sample plots to describe the state and changes taking place in forest ecosystems. The forest inventory methods used are primarily designed to suit the specific context and needs of each country regarding forest information. As a result, forest estimates lack international comparability and require harmonization to address the growing demand for consistent forest resource information at the European level (Gschwantner *et al.*, 2022).

This lack of comparable information also applies to NFIs in the Mediterranean region where definitions of terms such as forest, forest area, forest composition, deadwood, growing stock, biomass, increment and felling vary among countries. Additionally, there are differences in the methods used for both ground and remote sensing surveys, as well as for compiling statistics, with differences in sampling design, estimation methods and the precision of results.

Efforts to address these variations have gradually been incorporated into international reporting requirements, such as FAO's Global Forest Resources Assessment (FRA) (see for example FAO [2015, 2020]) and the State of Europe's Forests (SoEF) reports (see for example Forest Europe [2015, 2020]). These reports require countries to regularly assess their forest resources at intervals of 5 to 10 years using harmonized indicators – even if these differ from national definitions. Statistical analysis has also proven to be a valuable tool for harmonizing various forest indicators (see Case Study 7.1).

Use of earth observation satellites and remote sensing

Earth observation satellites

As earth observation satellite missions develop, opportunities to support forest monitoring and management have also opened up, including for the assessment of forest health at the regional scale (see for example Hansen *et al.* [2013]; Marín *et al.* [2021]; White *et al.* [2017]). Current international earth observation programmes, such as the European Copernicus programme with the Sentinel satellites or the United States of America Landsat programme and MODIS instrument, make data – and their processing standards – accessible online to facilitate their use. Some of their satellite sensors are specifically designed to analyse vegetation, providing data that are applicable in forest monitoring (Table 7.2).

The earth observation missions capture images of the entire surface of the earth in just a few days, creating an archive that allows for the monitoring of vegetation phenotypes throughout the year. By combining these data with reference ground data and utilizing AI, it is possible to automate the generation of forest maps, reducing human involvement, accelerating the process and lowering economic costs, while producing maps with greater spatial detail and at a higher frequency. However, managing earth observation satellite data for extensive areas like the Mediterranean region, poses challenges in developing tailor-made products. As the precision, scope and complexity of satellite imagery increase, the use of big-data and AI technologies is becoming essential for managing the growing quantity of data and developing new analytical methods to extract critical, ecologically relevant information. Incorporating these technologies into assessments will support more accurate mapping of ecosystem states, as well as the drivers and pressures they face, and their extent (Burkhard and Maes, 2017), based on explicit spatial information.

Remote sensing and satellite imagery

Remote sensing techniques, when coupled with ground-based surveys and satellite imagery, are extremely valuable tools that can support integrated assessments of forest ecosystems. Their use in the development of spatial indicators enables the quantification of information about forest properties, including forest fragmentation, species abundance, carbon stocks and other parameters.

For example, satellite imagery has been used to assess forest fragmentation in some parts of the

CASE STUDY 7.1

Filling gaps in data on deadwood in Mediterranean forests, Spain

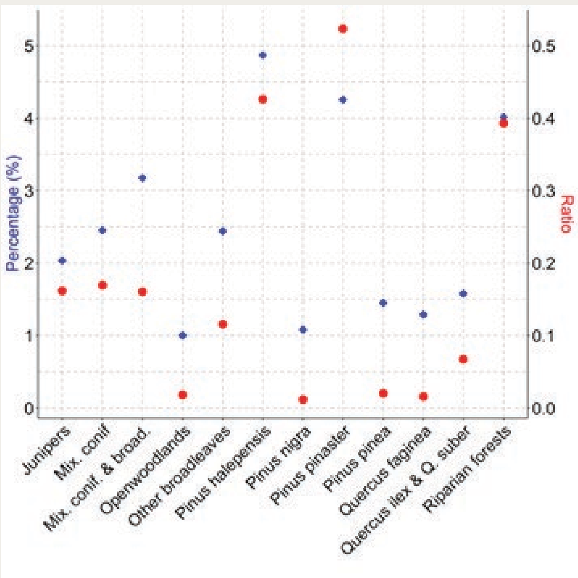
Forest deadwood is a recognized contributor to the provision of ecosystem services, such as forest biodiversity, carbon sequestration, and recreational and aesthetic values. But it also influences the risk and impact of forest disturbances.[i] For these reasons, deadwood biomass is a necessary parameter in international and national monitoring requirements and has recently been included in many national forest inventories (NFIs). Detailed information on deadwood in Mediterranean forests on a large scale is limited,[ii] and the differences in field monitoring protocols, particularly concerning the minimum size of the deadwood pieces recorded, vary among countries, complicating international comparisons. Consequently, efforts have been made to harmonize deadwood data.[iii] Furthermore, deadwood data from NFIs and other monitoring networks usually exhibit right-skewed distributions with a high number of zeroes and a long tail. This restricts the number of parametric statistical approaches available for deadwood modelling and prediction. In Spain, this issue was addressed using generalized additive models with a Tweedie distribution of errors and a spatial smooth to account for the spatial structure of deadwood.[ii, iv] The inclusion of the spatial smooth, however, limits the use of this model to the spatial extent of the field data and its surrounding areas. Therefore, this modelling approach should be developed for specific national or regional models. Here we have applied it with Spanish data.

The ratio of deadwood to living biomass (Equation 1) and the percentage of deadwood relative to total biomass (Equation 2) were estimated in the context of the Spanish NFI plots for each forest type, as follows:

$$Ratio = \frac{deadwood\ \ stock}{living\ \ biomass\ \ stock} \qquad \text{(Equation 1)}$$

$$Percentage = \frac{deadwood\ \ stock}{(deadwood\ \ stock\ \ + living\ \ biomass\ \ stock)} \qquad \text{(Equation 2)}$$

Ratio and percentage of deadwood in the main types of Mediterranean forests



where deadwood stock in megagrams per hectare (Mg/ha) is the sum of the deadwood biomass in standing and lying trees with a height equal to or greater than 1.30 metres (m), stumps and accumulations, and where living biomass stock, also in Mg/ha, accounts for both the above-ground and below-ground biomass of trees with a height equal to or greater than 1.30 m.

These two metrics were calculated by percentage of tree coverage, considering variability and international and national information requirements, and are shown in the figure here and in the appendix to this chapter (Table A7.1).

This study provides reference values that can be considered in other countries with similar forest types. However, it should be noted that validation would be necessary as environmental and management conditions in forests can vary a lot.

Sources:

i Nordström, E.-M., Nieuwenhuis, M., Başkent, E.Z., Biber, P., Black, K., Borges, J.G., Bugalho, M.N. *et al*. 2019. Forest decision support systems for the analysis of ecosystem services provisioning at the landscape scale under global climate and market change scenarios. *European Journal of Forest Research*, 138(4): 561–581. **https://doi.org/10.1007/s10342-019-01189-z**

ii Alberdi, I., Moreno-Fernández, D., Cañellas, I., Adame, P. & Hernández, L. 2020. Deadwood stocks in south-western European forests: Ecological patterns and large scale assessments. *Science of The Total Environment*, 747: 141237. **https://doi.org/10.1016/j.scitotenv.2020.141237**

iii Moreno-Fernández, D., Cañellas, I., Hernández, L., Adame, P. & Alberdi, I. 2025. Enhancing deadwood reporting for forest ecosystems: Bridge equations to convert deadwood measured at any diameter threshold to reference diameters. *Ecological Indicators* 163: 112112. **https://doi.org/10.1016/j.ecolind.2024.112112**

iv Moreno-Fernández, D., Hernández, L., Cañellas, I., Adame, P. & Alberdi, I. 2020. Analyzing the dynamics of the deadwood carbon pool in Spain through the European Level I Monitoring Programme. *Forest Ecology and Management*, 463: 118020. **https://doi.org/10.1016/j.foreco.2020.118020**

CASE STUDY 7.2

Embracing a collaborative and innovative approach to forest assessment and monitoring, Lebanon

The diverse forest ecosystems of Lebanon have long been under threat from human activities, which are leading to significant land degradation, increased wildfire events and biodiversity loss. These issues are further compounded by the impacts of climate change.

Historically, forest assessments in Lebanon have relied on traditional methods like ground-based surveys and low-resolution imagery, which faced challenges such as limited coverage, resolution constraints, resource intensity, and inconsistencies in data quality, leading to delayed insights.

In response, Lebanon has adopted a more integrated and innovative approach to forest assessments, supported by international and national organizations and the academic community. This approach fosters a synergistic relationship between research institutions and national authorities, as exemplified by several key initiatives:

- Academic partnerships: The collaboration between the Ministry of Environment and the Institute of the Environment of the University of Balamand plays a critical role in mapping and reporting forest fires and forecasting wildfire risks.
- Delineation and mapping of protected areas: This strategy was recently implemented for different types of protected areas through the United Nations Development Programme's (UNDP) STEP4Nature project in cooperation with the Ministry of Environment, one of the aims being to define and report on the exact coverage of protected areas in Lebanon in order to reach the global target of 30 percent, as stated in the Kunming-Montreal Global Biodiversity Framework.
- Geospatial mapping of greenhouse gases: Using geospatial technologies to quantify forest sector greenhouse gas emissions and removals, and contribute to Lebanon's reports to the United Nations Framework Convention on Climate Change (UNFCC), with support from UNDP Lebanon's climate change unit at the Ministry of Environment.
- Land degradation neutrality: Applying geospatial analysis to chart land degradation and set national land degradation-neutrality targets in alignment with the United Nations Convention to Combat Desertification (UNCCD), as facilitated by the Association for Forests, Development and Conservation (AFDC) in cooperation with the Ministry of Agriculture.
- Sustainable Planning Information Management System (SPIMS): Developed under the Sustainable Land Management in the Qaraoun Catchment (SLMQ) project with UNDP Lebanon, in cooperation with the Ministry of Environment. SPIMS employs machine learning to track urban encroachment into forest lands, promoting sustainable land use and informed decision-making while relying more and more on web-based workflows.

The inclusion of these collaborative and innovative methods in a national forest inventory aims to enhance monitoring capabilities, reduce operational costs, and improve data quality and consistency through standardized methodologies and technologies. This shift enables more informed and timely decision-making for forest management and conservation.

Lebanon's move towards an integrated forest assessment model underscores the vital role of collaboration between research bodies and governmental agencies. By embracing cutting-edge technologies and methodologies, Lebanon aspires to overcome traditional assessment limitations and secure a sustainable future for its forest ecosystems.

Table 7.2 Examples of currently operational satellites providing data applicable in forest monitoring

Satellite (sensor)	Data type	Revisit (day)	Cost policy	Reference
Landsat (ETM+, OLI)	Optical	16 (8)*	Free	https://landsat.usgs.gov/about-landsat
Sentinel-1 (SAR)	Radar	12 (6)†	Free	https://earth.esa.int/web/sentinel/user-guides/sentinel-1-sar
Sentinel-2 (MSI)	Optical	10 (5)†	Free	https://earth.esa.int/web/sentinel/user-guides/sentinel-2-msi
Terra and Aqua (MODIS)	Optical	2 (1)†	Free	https://modis.gsfc.nasa.gov/about/specifications.php
ALOS-2 (PALSAR)	Radar	14	Under research licence	http://global.jaxa.jp/projects/sat/alos2/index.html
Radarsat-2	Radar	24	Under research licence	https://mdacorporation.com/geospatial/international/satellites/ RADARSAT-2
TanDEM-X	Radar	11	Under research licence	https://www.dlr.de/dlr/en/desktopdefault.aspx/tab- id-10378/566_read-426/#/gallery/345
WorldView-2, -3, -4	Optical	1	Commercial	https://www.satimagingcorp.com/satellite-sensors
RapidEye	Optical	2.1–8.3	Commercial	https://www.satimagingcorp.com/satellite-sensors

Notes:

* Landsat 7 ETM+ and Landsat 8 OLI constitute a virtual dual programme with highly compatible data.

† Sentinel-1(A/B) and Sentinel-2(A/B) are dual satellite missions with opposed orbits: Sentinel-1 satellites have a 12-day repetition interval and together provide a 6-day repetition, while Sentinel-2 satellites have a 10-day interval, providing together a 5-day repetition. Terra and Aqua also make up a dual satellite system that carries the MODIS instrument: each satellite has a 2-day repetition interval, and together they provide a daily repetition interval.

Source: Gómez, C., Alejandro, P., Hermosilla, T., Montes, F., Pascual, C., Ruiz, L.A., Álvarez-Taboada, F., Tanase, M. & Valbuena, R. 2019. Remote sensing for the Spanish forests in the 21st century: a review of advances, needs, and opportunities. *Forest Systems*, 28(1): eR001–eR001. https://doi.org/10.5424/fs/2019281-14221

Mediterranean region, providing spatially explicit metrics of forest fragmentation and habitat loss (De Giorgi, 2018; Geri, Rocchini and Chiarucci, 2010; Martinez del Castillo *et al.*, 2015).

A number of global and regional maps of forests are available, including for the Mediterranean basin, which have been generated from remote sensing data and which differentiate between open and dense forests, as well as between generic forest types, such as evergreen, broadleaved, coniferous and mixed forest (Table 7.3). However, they differ in terms of their spatial and temporal scales and present limitations in terms of their spatial and statistical accuracy.

Today, as satellite imagery becomes more precise, extensive and complex, using big-data and AI technologies is becoming increasingly important for managing the growing amount of data and developing new ways of analysing them to extract critical, ecologically relevant information (see Case Study 7.3), which can be used in many ecosystem management applications.

Recent advancements in the Mediterranean

Significant progress has been made in forest assessments in the Mediterranean in recent years. Mapping forest disturbances has made great strides, especially in detecting areas with a high frequency of wildfires and identifying the factors that contribute to their occurrence (Cilli *et al.*, 2022; Mohajane *et al.*, 2021); estimating above-ground biomass (Bulut, 2023; Castaño-Díaz *et al.*, 2017); and for evaluating soil carbon stocks (López-Senespleda, Calama and Ruiz-Peinado, 2021).

To improve data coherence in the region, the DPSIR framework has been adapted for use in a number of other integrated assessment studies that evaluate the status and trends of Mediterranean forests. For example, studies such as those by Balzan *et al.* (2019) and Vizinho *et al.* (2021) have used the DPSIR framework to examine the impacts of climate change on Mediterranean forests. These studies highlight the importance of incorporating

CASE STUDY 7.3

Innovative technologies, Algeria

Due to its geographical location, and topographic and bioclimatic diversity, Algeria has a remarkable range of natural areas extending from the coastline to the Sahara Desert, with mountains, plains and steppes. The country faces a variety of pressures, including urbanization, unsustainable logging, fires, the degradation of wetlands, various types of erosion, and climate change, all of which threaten its natural heritage. To address these challenges, conservation and rehabilitation efforts are being deployed using advanced technologies, such as Geographic Information Systems (GIS), remote sensing and artificial intelligence (AI) to monitor landscapes and provide integrated studies.

A prime example of the sustainable management of Mediterranean forests in Algeria is provided by the ongoing assessment and rehabilitation operations carried out by the Forestry Branch of the Ministry of Agriculture and Rural Development. The national forest inventories conducted in 1980 and 2009 provided the first maps of forest ecosystems, while the ongoing third inventory, using modern technologies like terrestrial 3D-Lidar scanners, represents an innovative initiative.

At the same time, as part of the fight against desertification, a national desertification vulnerability map was drawn up in 2010. The detailed map produced showed vulnerable areas and covered 27 435 000 hectares (ha), providing a decision-making tool for combating desertification. A recent report to the United Nations Convention to Combat Desertification highlighted the country's progress towards implementing the 2030 Agenda for Sustainable Development.[i] Concurrently, a programme to rehabilitate the Green Dam was launched in 2023, with an integrated approach aimed at mitigating desertification over an area of 4.7 ha, 1 500 kilometre (km) long and 20 km wide, between the 200 millimetre (mm) and 300 mm rainfall isohyets.[ii, iii]

There have been significant advances in the management and preservation of Algeria's forests in the face of climate and global change.[iv] Integrated ecological rehabilitation initiatives have been launched in degraded ecosystems. For example, a national project began in 2021 to rehabilitate cork oak forest production landscapes with support from FAO and the Global Environment Facility (GEF).* Researchers at universities and research centres are also mapping the vulnerability of ecosystems to degradation and the risk of collapse.[v, vi] Studies modelling the ecological niches of Mediterranean woody species supplement these efforts.[vii, viii, ix]

Going forward, FAO is committed to supporting the Algerian Government in formulating a financing proposal to the Green Climate Fund secretariat, focused on improving the climatic resilience of the steppes and dry forest areas of the Green Dam. The case of Algeria highlights the many challenges facing Mediterranean forests in terms of holistic forest management. Although major efforts are being made with GIS tools, remote sensing and AI, the methods for assessing ecosystems need to be standardized in order to better understand biodiversity trends, ecological processes, and human pressures and their impacts on ecosystems.

Note:

* See https://www.thegef.org/projects-operations/projects/9806

Sources:

[i] United Nations Convention to Combat Desertification. 2022. *Algeria country report 2022*. PRAIS4. https://www.unccd.int/our-work-impact/country-profiles/algeria/country-report/2022

[ii] MATE (Algerian Ministry of Environment and Land-Use Planning). 2014. *Cinquième rapport national sur la mise en uvre de la Convention sur la diversité biologique au niveau national*. https://www.cbd.int/doc/world/dz/dz-nr-05-fr.pdf

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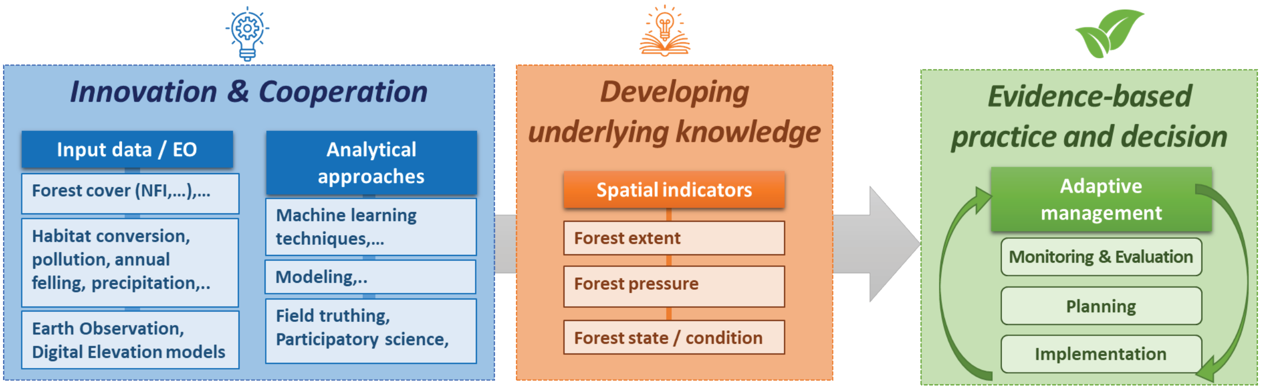
Table 7.3 List of potential datasets with regional coverage to be used for mapping forest area and assessing forest fragmentation in the Mediterranean region

Data	Owner	Coverage	Spatial resolution	Time series
Global land cover	Copernicus Land Monitoring Service	Global	100 m x 100 m	2015–2019 (annual time laps)
Global 2010 tree cover, data from Global Forest Watch*	Global Land Analysis & Discovery (GLAD) lab at the University of Maryland, Google, United States Geological Survey (USGS) and National Aeronautics and Space Administration (NASA)	Global	30 m x 30 m	Status 2000, 2010
Tree cover loss, data from Global Forest Watch*	GLAD lab at the University of Maryland, Google, USGS and NASA	Global	30 m x 30 m	Change: 2001–2022 (annual time laps)
Tree cover gain, data from Global Forest Watch*	GLAD lab at the University of Maryland, Google, USGS and NASA	Global	30 m x 30 m	Change: 2000–2020 (annual time laps)
Global 30 m Landsat tree canopy†	NASA	Global	30 m	2000, 2005, 2010, 2015
PALSAR-2/PALSAR/JERS-1 mosaic and forest/non-forest maps‡	Japanese Aerospace Exploration Agency (JAXA)	Global	25 m	2007, 2008, 2009, 2010, 2015, 2016, 2017, 2018
			100 m	2007, 2008, 2009, 2010

Notes:

* https://www.globalforestwatch.org/map/
† https://lcluc.umd.edu/metadata/global-30m-landsat-tree-canopy-version-4
‡ https://www.eorc.jaxa.jp/ALOS/en/dataset/fnf_e.htm

Figure 7.3. Framework for integrated mapping and assessment of Mediterranean forest ecosystems



complexity into ecosystem assessments to support evidence-based decision-making and to develop adaptive management strategies that enhance forest resilience.

Since 2018, the FAO Committee on Mediterranean Forestry Questions – *Silva Mediterranea*, the EEA and the University of Málaga have been building on an agreed-upon delineation method and definition of Mediterranean forests (FAO and Plan Bleu, 2018), working together using innovative approaches and tools to develop a knowledge base capable of supporting integrated forest assessments in the region (Figure 7.3).

A Mediterranean-wide forest cover map that is comparable across the region was produced as a baseline to support the development of key forest indicators, such as forest area, and to understand forest condition and dynamics in the Mediterranean region (FAO *et al.*, 2022). The methodological approach and workflow for developing such a baseline were successfully proposed and tested based on big data from satellite images and large ground truth databases (Burgueño *et al.*, 2023). The machine learning model developed for mapping is versatile and can be applied to other regions. Additionally the spectral library created for the model's training can use data from different years, allowing repeatability over time. The methodology is available for free under an open source licence.[23]

The results of the land cover map were compared with the Global Land Cover map. The validation dataset showed that the overall accuracy of the map exceeded 90 percent, confirming the reliability of the methodological workflow used to generate a Mediterranean-wide land cover map processed using big data from satellite images and large ground truth databases.

In addition to identifying forest land classes and quantifying forest area (or tree-covered area, depending on the product's technical specifications), new technologies show great potential for evaluating forest characteristics and parameters. Efforts have been made to identify and monitor other characteristics of Mediterranean forests using remote sensing.

In a recent study on the classification of forest types, García Millán *et al.* (2022) created a map of dominant tree species in Mediterranean forests using multispectral data from Sentinel-2 Multispectral Imager (MSI) and NASA's ASTER digital elevation model. To create this map, data from national inventories and expert knowledge were collected and harmonized, which further resulted in a comprehensive database and spectral library of Mediterranean forests.

Using homogeneous satellite data and reliable technologies enables the creation of a forest cover map that is comparable for all Mediterranean nations and constitutes a reference at the regional level in terms of geographical, temporal and thematic resolution, addressing a significant information gap in the region. Further validations at the country and local levels would still be needed to confirm that this Mediterranean-wide map correctly represents the forest area at the national and subnational scales, especially in the eastern and southern parts of the Mediterranean region, where *in situ* data are in many cases inaccessible or unavailable for validation.

Conclusions and way forward

This chapter highlights the importance and benefits of advancing an integrated assessment of forests across the Mediterranean region. However, integrating diverse data sources and methodologies poses several challenges. Adapting the DPSIR framework to Mediterranean forests will involve recognition of the drivers and pressures specific to the region. Data gaps hinder a thorough analysis of forest ecosystems and relevant socioeconomic indicators. Integrating biophysical and socioeconomic models involves methodological complexities that require interdisciplinary collaboration and expertise. Finally, resource constraints, including limited funding and institutional capacity, restrict the scope and scale of integrated assessments and reduce their replicability at the necessary intervals for regular monitoring and the assessment of change over time.

There is a need for agreed definitions, indicators and classifications on a regional level, but which avoid oversimplification of complex ecological realities and heterogeneity. Improving data availability, quality and interoperability is essential for enhancing integrated assessment efforts in Mediterranean forests. Open-access repositories and data-sharing platforms facilitate broader access to information and promote transparency and collaboration. Designing an interactive platform for hosting, maintaining and updating these data over time is crucial. For example, the FISE serves as an entry point for sharing information by bringing together data, information and knowledge gathered or derived from key forest-related policy drivers, and could be an effective model for the Mediterranean to follow. Such a data repository also requires the identification or establishment of a secretariat or body to ensure interoperability and coherent use of the data for integrated forest assessments. In

[23] https://doi.org/10.5281/zenodo.7462308

close agreement and collaboration with countries, this body should inform and guide forest policy and practice in the Mediterranean region. *Silva Mediterranea*, which is already established and addressing region-wide forest issues, could be a relevant body to fulfil such a role.

Satellite imagery and remote sensing technologies provide valuable spatial data that supplement ground-based observations and socioeconomic information, but the availability of data can often be limited. Quality assurance procedures, including data validation and verification, help ensure the reliability and accuracy of integrated assessment results. However, uncertainties associated with data gaps and modelling assumptions require transparent communication and sensitivity analysis to inform decision-making processes.

Addressing these challenges requires enhanced collaboration, capacity building and knowledge sharing among stakeholders, which are essential for improving the integrated assessment of Mediterranean forests. Engaging local communities, non-governmental organizations and other stakeholders in data-collection and monitoring efforts enhances the relevance and inclusivity of assessments and helps knowledge sharing and participatory decision-making processes.

Capacity-building initiatives, including training programmes and workshops, empower local stakeholders with the necessary skills and knowledge to participate effectively in integrated assessment processes. Establishing networks and partnerships among research institutions, government agencies and international organizations fosters synergies and furthers the exchange of best practices and lessons learned.

There is a clear and urgent need to establish integrated forest assessments in the region, especially in the context of climate and global change and their impacts on these vital forest ecosystems. Despite the many hurdles involved, it is possible, using agreed-upon definitions and indicators, to establish data repositories and a coordinating body, and to implement integrated forest assessments that inform actions and decisions regarding forest ecosystems in the Mediterranean region, building on already established frameworks such as the DPSIR.

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Chapter 7 appendix

Table A7.1 Ratio of deadwood to living biomass and deadwood percentage for main Mediterranean forest types and coverage, Spain

Forest type	Coverage (%)	Ratio	Percentage	N plots
Riparian forests				
	0–10	0.029 (0.058)	0.026 (0.045)	52
	10–20	0.041 (0.094)	0.033 (0.071)	17
	≥20	0.412 (5.211)	0.041 (0.104)	1313
	All	0.393 (5.08)	0.04 (0.102)	1382
Juniperus spp. stands				
	0–10	0.015 (0.054)	0.013 (0.044)	18
	10–20	1.236 (6.64)	0.078 (0.218)	78
	≥20	0.047 (0.518)	0.014 (0.07)	703
	All	0.162 (2.148)	0.02 (0.097)	799
Mixtures of conifer species				
	0–10	0.018 (0.034)	0.016 (0.031)	38
	10–20	0.14 (0.508)	0.055 (0.161)	47
	≥20	0.176 (3.111)	0.023 (0.079)	1102
	All	0.17 (3)	0.025 (0.083)	1187
Mixtures of conifer and broadleaves species				
	0–10	0.687 (3.523)	0.071 (0.204)	83
	10–20	0.791 (6.79)	0.064 (0.175)	131
	≥20	0.099 (1.868)	0.028 (0.08)	2054
	All	0.161 (2.508)	0.032 (0.096)	2268
Open woodlands				
	0–10	0.004 (0.01)	0.004 (0.01)	18
	10–20	0.005 (0.02)	0.005 (0.018)	168
	≥20	0.02 (0.247)	0.011 (0.049)	1160
	All	0.018 (0.23)	0.01 (0.046)	1346
Other broadleaves (*Ilex aquifolium*, *Ceratonia siliqua*, *Olea europaea*, *Arbutus unedo*, etc.)				
	0–10	0.011 (0.028)	0.01 (0.024)	53
	10–20	0.445 (4.179)	0.033 (0.125)	117
	≥20	0.093 (1.242)	0.024 (0.08)	1482
	All	0.116 (1.618)	0.024 (0.083)	1652
Pinus halepensis forests				
	0–10	4.057 (16.055)	0.13 (0.280)	61
	10–20	3.682 (11.382)	0.23 (0.354)	146
	≥20	0.16 (1.986)	0.037 (0.105)	2614
	All	0.426 (4.086)	0.049 (0.142)	2821
Pinus pinea forests				
	0–10	0.005 (0.008)	0.005 (0.008)	17
	10–20	0.01 (0.034)	0.009 (0.029)	39
	≥20	0.021 (0.133)	0.015 (0.05)	711
	All	0.02 (0.129)	0.014 (0.048)	767

Forest type	Coverage (%)	Ratio	Percentage	N plots
Pinus nigra forests				
	0–10	0.002 (0.003)	0.002 (0.003)	15
	10–20	0.011 (0.036)	0.009 (0.031)	44
	≥20	0.012 (0.032)	0.011 (0.025)	1602
	All	0.012 (0.032)	0.011 (0.025)	1661
Pinus pinaster forests				
	0–10	5.319 (28.208)	0.172 (0.312)	89
	10–20	0.685 (2.935)	0.098 (0.22)	80
	≥20	0.319 (4.309)	0.035 (0.111)	2150
	All	0.524 (6.974)	0.043 (0.132)	2319
Quercus faginea forests				
	0–10	0.011 (0.009)	0.01 (0.008)	6
	10–20	0.006 (0.016)	0.006 (0.015)	83
	≥20	0.017 (0.083)	0.014 (0.039)	694
	All	0.016 (0.079)	0.013 (0.037)	783
Quercus ilex and *Q. suber* forests				
	0–10	0.555 (4.239)	0.06 (0.156)	90
	10–20	0.029 (0.24)	0.015 (0.067)	335
	≥20	0.058 (2.08)	0.015 (0.056)	3348
	All	0.067 (2.067)	0.016 (0.062)	3773

Note: N is the number of plots used in the Spanish National Forest Inventory; standard deviations are shown in parentheses.

Chapter 8
Conclusions: towards a sustainable Mediterranean future

The Mediterranean region is at a critical crossroads, facing escalating socioeconomic pressures, environmental degradation and climate-related risks. In this context, the 2025 edition of the status of Mediterranean forests (SoMF) provides a comprehensive analysis of the region's forest ecosystems, drivers of change and emerging solutions. This recurrent publication is released approximately every 5 years and serves as a vital instrument for monitoring and assessing forest resources and emerging issues in the region. It provides a trusted source of information for experts, policymakers, practitioners, stakeholders and the broader public. After analysing the growing challenges and pressures faced by Mediterranean forests, the 2025 edition makes a clear call for policymakers, practitioners and donors to intensify and scale up their efforts to address these challenges and secure the future of these vital ecosystems.

A region under pressure but rich in opportunity

Demographic growth, uneven economic development and persistent unemployment – especially among women and youth – continue to put a strain on natural systems. Coupled with climate change, unsustainable consumption patterns and geopolitical instability, these pressures expose the vulnerability of forest ecosystems and the communities that rely on them for their livelihoods (Chapter 1).

Despite these challenges, the region also holds untapped potential for inclusive growth, ecological restoration and green transformation. Forests are expanding overall, albeit not uniformly, and there is growing regional momentum for the restoration of degraded land, and community-based and sustainable forest management.

The latest data available for Mediterranean countries, obtained from the Forest Resources Assessment 2020, reveal that forest area in the region has increased by 12 percent since 1990, with notable gains in Western Mediterranean countries. However, the rate of forest expansion has slowed, and Southern Mediterranean countries are lagging behind. Overall, forest biomass, carbon stocks and the coverage of protected areas are all increasing (Chapter 2).

Although the expansion of forests in Mediterranean countries is encouraging, they still require careful monitoring and sustained attention. Forest degradation, fragmentation and vulnerability to climate change are persistent issues. These are often associated with poor land management and limited ecological resilience. The degradation of Mediterranean forests results from regional temperatures rising faster than the global average, prolonged and extreme droughts and land-use changes – where expanding urban and agricultural land in the south coexists with land abandonment in the north, which leads to rural depopulation, forest regrowth and increased fire risk. The drivers of degradation also include overgrazing and outbreaks of both invasive and native pests and pathogens, contributing to forest decline and diebacks. Increased frequency and intensity of wildfires pose a high risk to forest and agricultural landscapes, with more than 5.5 million hectares burnt in the Mediterranean ecosystems area from 2010 to 2030, including 1.7 million hectares of forest, and a general upward trend in mean burnt area (Chapter 3).

The Mediterranean countries are committed to tackling these challenges through collaborative action, as demonstrated by the Agadir Commitment (2017), the Brummana Declaration (2019) and the Antalya Declaration (2022), in which they collectively pledged to restore 8 million hectares of degraded land by 2030. Despite several shortcomings, including oversimplified practices that equate restoration with reforestation, a lack of site-specific strategies, insufficient post-project monitoring and inadequate long-term funding and governance mechanisms, there is an increasing emphasis on science-based, participatory restoration practices that involve local communities – including women and youth – rely on multiple species, integrate traditional knowledge, and mobilize both public and private resources. The regional standards developed by the Society for Ecological Restoration offer principles and indicators for effective forest and landscape restoration (FLR). Their application can strategically support better planning, implementation and evaluation (Chapter 4).

Several pilot projects provide effective models for integrated fire management in the Mediterranean region. These successfully emphasize the importance of prevention strategies, including integrated planning, fuel management, infrastructure development, risk assessment and community involvement; post-fire restoration, which is crucial for soil stabilization and erosion control, and ecosystem recovery; and international and regional cooperation, which includes data sharing, knowledge exchange and coordinated response efforts (Chapter 5).

A significant milestone has been the United Nations World Restoration Flagship "Restoring Mediterranean forests", which highlights the regional momentum and represents a substantial endeavour for addressing the degradation of forest ecosystems in one of the planet's most critical biodiversity hotspots while also scaling up good practices for post-fire restoration.

As the urban population increases, the importance of urban and peri-urban forests in strengthening resilience and improving well-being at the rural–urban interface is underscored, as they are vital for enhancing ecological connectivity, social inclusion and climate resilience, and achieving restoration goals. Strategic planning and multifunctional investments in urban and peri-urban forests can help mitigate land degradation while enhancing livelihoods (Chapter 6).

The restoration of Mediterranean forest ecosystems is considered viable in many contexts, but projects often face several shortcomings, including:

- **Fragmented funding.** Sustainable finance for FLR is scattered and underleveraged. Strategic integration across sectors and investment pipelines is necessary, involving private investors through incentives and risk-sharing mechanisms.
- **Inconsistent pre- and post-intervention monitoring.** Baseline assessment and evaluation of projects require continuous monitoring. The region is dealing with data gaps, inconsistent forest classifications and underutilization of emerging technologies. Coordination and investment in monitoring are urgently needed across the region (Chapter 7).
- **Weak institutional frameworks.** These require the establishment of interministerial coordination, capacity building, inclusive governance, and enhanced participation in regional platforms.

A shared agenda for forest resilience

Mediterranean forest landscapes are at a turning point. Looking ahead, their future will be shaped not only by how they respond to local pressures, such as climate change, land degradation and demographic shifts, but also by how they contribute to global sustainability goals. With strategic action and research-driven innovation, Mediterranean forest ecosystems can become both a regional asset and a global model of resilience.

The future of Mediterranean forest resources relies on their capacity to deliver multifunctional benefits, including climate mitigation through carbon storage, biodiversity conservation, sustainable livelihoods, and resilience at the landscape level to extreme events like wildfires and drought. Their future also depends on coordinated actions that align ecological integrity with social and economic development.

At the global level, Mediterranean forests offer lessons for other climate-vulnerable regions. They embody the challenges of managing semi-arid landscapes amid increasing water stress, urbanization and social complexity. Thus, they are both ecological treasures and strategic testing grounds for integrated, people-centred restoration and sustainable management practices.

In this context, research and innovation are foundational pillars for the next chapter of Mediterranean forestry, as highlighted by the Mediterranean Forest Research Agenda 2030 (MFRA) released by EFIMED. A science-based and collaborative approach is essential to drive this transformation forward, focusing on priority areas that align closely with the themes explored in this volume, including:

- Enhancing the resilience and adaptive capacity of Mediterranean forests in response to climate change and increasing disturbances.
- Promoting FLR through scalable, inclusive and ecologically sound approaches while supporting the growth of a sustainable forest-based bioeconomy grounded in local value chains and low-impact practices.
- Strengthening the urban–rural interface by leveraging urban and peri-urban forests as tools for integration, well-being and ecological connectivity.
- Advancing forest data and monitoring, and forest-related knowledge systems, including through the use of remote sensing, artificial intelligence and participatory science.

The SoMF 2025 also closely aligns with other strategic documents relevant to the Mediterranean region. The Union for the Mediterranean's GreenerMed agenda sets out a vision for sustainable resource use, climate adaptation and pollution reduction. The findings of the SoMF 2025 reflect the forest sector's contribution to and support for implementing GreenerMed's core themes, which include a green, circular and socially inclusive economy alongside ecosystem restoration. Similarly, the Mediterranean Action Plan of the United Nations Environment Programme's (UNEP/MAP) Medium-Term Strategy 2022–2027 envisions a healthy, sustainable and climate-resilient Mediterranean Sea and coastline, with the goal of achieving the 2030 Agenda and its Sustainable Development Goals (SDGs). Its focus on protecting and restoring Mediterranean ecosystems and biodiversity intersects directly with the forest-related priorities outlined in this volume.

Implementing these agendas requires strong partnerships between governments, scientific institutions, civil society and local communities. But, more importantly, it will require a shared vision of Mediterranean forests as active agents for recovery, innovation and sustainability.

This volume calls for a bold shift in thinking and action to move beyond sectoral silos in order to prioritize sustainable practices, foster inclusive growth and lead the way towards achieving the region's forest goals, emphasizing research, innovation and, above all, dialogue between science, people and policy.

Building on the foundations of the 2013 and 2028 reports, the 2025 edition of the status of Mediterranean forests provides a comprehensive and forward-looking assessment of the region's forests at a time of unprecedented change, drawing on updated data, regional cooperation and insights from stakeholders across the Mediterranean.

Following a contextual overview of socioeconomic and demographic trends in the region, the status of Mediterranean forests 2025 then provides a review of the region's forests resources and dynamics, and the threats they are currently facing, such as climate change, weather extremes, pests and diseases, land-use change and wildfires. It reports on current wildfire statistics and highlights the region's innovative efforts towards integrated fire management. The publication also explores the pivotal role these forests play in supporting livelihoods, conserving biodiversity and contributing to the global climate and sustainability agenda. It examines the growing recognition of the role that urban forests and peri-urban forests at the rural–urban interface, the global impacts of the strategic designation of the Mediterranean as a United Nations World Restoration Flagship, and the importance of long-term, harmonized monitoring as a tool for effective forest conservation, restoration and sustainable use across the region.

The findings of the status of Mediterranean forests 2025 emphasize the need for decisive and coordinated action to reverse forest degradation, invest in long-term resilience, and recognize the value of Mediterranean forests not only as natural assets but also as a foundation for inclusive and sustainable societies.

Contact information
Forestry Division - Natural Resources and Sustainable Production
https://www.fao.org/forestry/en/
NFOI@fao.org
@FAOForestry

Food and Agriculture Organization of the United Nations
Rome, Italy

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