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Mediterranean Forest Research Agenda 2030

Magda Bou Dagher Kharrat, Inazio Martinez de Arano, E Zeki-Başken, Sarah Feder, Sarah Adams, Siebe Briers, Bruno Fady, Francois Lefèvre, Elena Górriz-Mifsud, Eduard Mauri, et al.

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Mediterranean Forest Research Agenda **2030**

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Foreword

More than ten years have passed since we developed the first **Mediterranean Forest Research Agenda 2010-2020**. The MFRA acted as both a compass and catalyst, which together with the work of the EFI Mediterranean Forest Facility (EFIMED) and its committed network, resulted in important advances for a better equipped, coordinated, and structured forest research community in the Mediterranean region. That was possible because the MFRA was not only developed collectively but it was also implemented collectively. Let me just give three examples of the MFRA implementation.

First, **FORESTERRA** "Enhancing FOrest RESearch in the MediTERRAnean", the only ERA-NET forest initiative with a regional perspective. FORESTERRA was funded under the EU 7th Framework Programme to advance scientific cooperation in Mediterranean-area countries (including EU and non-EU member states) and with countries from other Mediterranean Climate Areas (MCA) in this case, Australia, South Africa, Chile and California. It not only provided funds for transnational projects but it was the first transnational initiative to bring together policymakers from Ministries responsible for forest research to agree on a common vision and common priorities regarding Mediterranean forests and forest science. Second, the **AGORA project**, also funded under the 7th Framework programme, mobilised targeted funds to advance forest research capacities in Morocco and Tunisia through scientific "twinning" partnerships with forest research organisations in Spain, Italy, and Portugal. The project resulted in a new generation of leading forest scientists in Tunisia and Morocco. Third, the **MEDfOR Masters Programme**, an international MSc funded by the Erasmus+ Programme of the European Union which has been running since 2012 to provide higher education on forests and their sustainable management for a more prosperous Mediterranean region. The Master is a collaborative initiative between seven universities from four Mediterranean countries, which demonstrates the importance of transnational collaboration.

However, despite the achievements made so far through the implementation of the past MFRA, the threats and challenges affecting Mediterranean forests have not diminished but only increased. Fortunately, advances in forest science such as the ones referred to throughout this document make all of us aware of the scale of the problem but also of the possible solutions. I hope that the MFRA 2030 will inspire at scientific, policy and practice level the right level of attention, funding, and action to ensure the resilience of Mediterranean forests to global change as well as the sustainability of forestry activities for the benefit of people and nature. Since climate projections show that Mediterranean-like conditions will expand to large parts of adjacent areas, the MFRA 2030 can also be of great value for scientists and policymakers beyond the Mediterranean region.



Marc Palahi
Director
European Forest Institute



1. Introduction

The first **Mediterranean Forest Research Agenda 2010-2020** (MFRA 2020) (Palahi *et al.*, 2009) was written over a decade ago now. Since then, accelerating climate, ecological, socioeconomic and political changes have been transforming the complex socio-ecological systems of the Mediterranean. In this context, pressing environmental challenges (e.g., forest fires, droughts, extreme weather events) demand urgent attention from local and regional political agendas.

The need for action to strengthen the resilience of Mediterranean forest ecosystems was also highlighted during the COVID-19 pandemic. The pandemic underlined the increasing importance of peri-urban and urban forests for recreational activities and for coping with mental stress. Furthermore, the Russia-Ukraine conflict and other global geopolitical instabilities and uncertainties have dramatically changed the commercial flows of energy and wood resources. They have particularly affected demand and market prices for wood-based biomass for energy production, such as fuelwood and pellets, in several Mediterranean countries.

In the last ten years, new high-level forest-related strategies have been approved, aiming to positively influence the future of forests (Lier *et al.*, 2022). At the global level, the Sustainable Development Goal number 15 of the 2030 Agenda for Sustainable Development of the United Nations adopted in 2015, aims to “protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss”. At European level both the new EU Strategy for Biodiversity (EC, 2021a), and the new EU Forest Strategy for 2030 (EC, 2021b) support the implementation of the European Green Deal (EC, 2019), and call for ambitious goals including increasing protected areas up to 30% of the total land area, and planting 3 billion trees, amongst other interventions to restore degraded ecosystem services by 2030.

Since the MFRA 2020, there have been important advances in understanding the ecological, economic and social aspects of Mediterranean forests. At the same time, the system’s complexity and emerging challenges also highlight new questions, possible future developments, and critical gaps in our understanding of the resilience, biodiversity, functioning, and dynamics of forests.

The Mediterranean Forest Research Agenda 2030 (MFRA 2030) constitutes a timely review of the past decade’s achievements against the previous research priorities and at the same time looks to where attention should focus for the next ten years. Some thematic areas from the MFRA 2020 have made significant progress thanks to the MFRA spotlights, while others warrant continued attention and were included in the MFRA 2030 considering the magnitude of work that still needs to be done.

In preparing for the MFRA 2030 we collected information on the most important research achievements, significant breakthroughs and innovations of the past decade. For this exercise, we engaged the network of the European Forest Institute’s Mediterranean Facility (EFIMED), and the broader Mediterranean forestry community. The main findings of this consultation are summarised in the **MFRA 2020 Survey Report**, along with highlighted projects and publications that emerged from the past ten years of Mediterranean forest research.

The process resulted in defining four priority areas to be addressed in the next decade:

- Forest resilience in a context of global change related forest disturbances
- Conservation and management of biodiversity and forest genetic resources
- Forest management addressing trade-offs and synergies between multiple ecosystem services
- Social and business innovations and policy instruments supporting the Mediterranean forest-based bioeconomy.

We expect that the MFRA 2030 will spur researchers and practitioners into further action, and will also serve as a reference for policymakers and funding agencies to support global efforts to strengthen Mediterranean forests’ resilience in the face of climate and biodiversity crises, new social demands and demographic challenges. Furthermore, if Mediterranean-like conditions expand to large parts of adjacent areas, as predicted by climate scientists, the MFRA 2030 will become relevant for an even wider community of stakeholders.



Photo: Adobe Stock

2. A complex outlook for Mediterranean forests

Over recent decades a gradual abandonment of farmland has resulted in spontaneous forest regrowth in particular in Mediterranean Europe (Valladares *et al.*, 2014). Between 2010 and 2015, forests in the Mediterranean increased their cover by 2% and occupied 10% of the total area of Mediterranean countries. However, this proportion varies largely between the different countries.

On the other hand, in southern Mediterranean countries, very high pressure on forested areas is coupled with human demographic increase, the expansion of crops and higher livestock pressure, as well as an overexploitation of water resources (Peñuelas and Sardans, 2021). Today there is an increased urgency to strengthen forest resilience and adaptive capacity of forests in relation to environmental and socio-economic uncertainties. Many current concerns about forests are indisputably interconnected. For example, a regional water-biodiversity-fire nexus seems to be taking shape. Biodiversity is a key asset supporting many important ecosystem services provided by Mediterranean forests, but is under pressure by changing forest hydrological functions, which are affected by land use change and climate change. And in turn, these structures and functions are strongly interwoven with the negative impacts of wildfires. The latter risk emphasises that forests need protection from human impacts, and in some cases, humans also need protection from the negative externalities that forests can inflict upon them.

We flag the emergence of so-called ‘wicked’ problems, reflecting the complex dynamics of uncertainty. Wicked problems do not have single, straightforward solutions; rather, they must be addressed through holistic, coordinated, and sustained actions. In relation to forests, these problems are typically driven by global crises, such as extreme climatic events, biodiversity loss, or pests and disease outbreaks, or their combinations.

Such problems are normally combined with:



Societal processes, such as population growth, migration, changing consumption patterns, or urbanisation and rural land abandonment.



Persistence of an **economic development model** still dominated by natural resource overexploitation, water pollution and use of non-renewable energy resources.



Limited **governance capacities** of institutions and public administrations, as well as fragmented and /or overlapping, uncoordinated policies and competences.

Source: EFIMED / In-house production

One more layer of complexity can be added, which is the social, multifunctional aspect of Mediterranean forests. The traditional perception of “forest for wood production” has shifted to the modern concept of “forest for multiple ecosystem services provision”, including biodiversity conservation, recreation, bioenergy production, and climate change mitigation. This latter concept, mainly reinforced by the mass media, is a fast-moving target compared to the implementation of strategic actions applied by administrations to embrace those needs.

Mass media play a major role in how society perceives and reacts to the full range of problems facing forests (social, environmental, and economic), as well as their underlying causes and shaping the collective imagination for solving them (Fabra-Crespo *et al.*, 2015). Although these perceptions arise from complex interactions among socio-economic, institutional, political, and technical system components, they need time to surface and be more widely adopted by society. Associated elements are often analysed by researchers and understood by decision- or policymakers separately within disciplinary silos, which neglect interactions and feedback that can otherwise lead to more rapid responses (Wunder *et al.*, 2021). Understanding and exploring the potential of diverse stakeholders' input into forestry research and management is essential for identifying high-impact intervention points and better informed policymaking.

In the following sections, we provide a common vision for the future of Mediterranean forest research where we present the four priority themes identified through a participatory process.

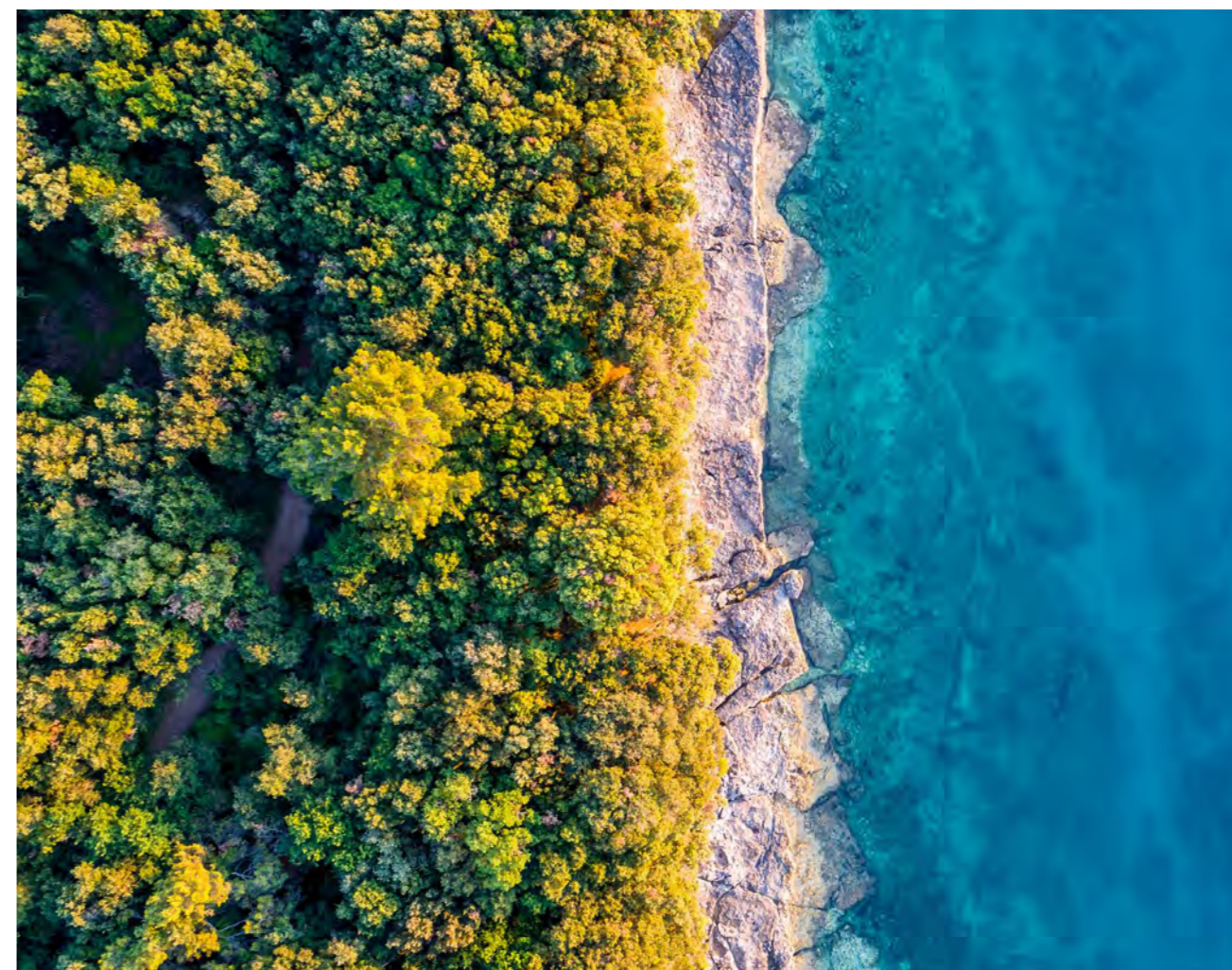


Photo: Adobe Stock

3. Priority themes

In response to the above-described challenges and needs, we identified four topical priority areas of research:

Theme 1: Forest resilience in a context of global change related forest disturbances

The Mediterranean Basin is considered a primary hotspot for climate change, in terms of the region's changing temperature, and mean precipitation, and their interannual variability (MedECC 2020). For Mediterranean forests, a key implication is increasing aridity, as manifested by a large decrease in mean precipitation and an increase in its variability throughout the dry season; water is the primary limiting factor for the provision of forest ecosystems services (Ruiz et al., 2020).

The combination of climate change, anthropogenic disturbances including overexploitation of forest resources, human-induced fires and deforestation, and other aspects of global change will continue to affect Mediterranean forest vegetation (Gauquelin *et al.*, 2018).

The paper by Peñuelas and Sardans (2021) highlighted that increasing drought conditions, over-exploitation, pest expansion, fire, species invasions, pollution, and soil degradation are combining to drive forest regression and dieback in several areas of the Mediterranean Basin. Moreover, disturbance by livestock and over-exploitation in some Mediterranean areas have significantly increased, thus exacerbating the negative effect of reduced natural precipitation (Doblas-Miranda *et al.*, 2017; Riedel *et al.*, 2013). Additionally, in a paradoxical contradiction, rapidly decreasing livestock pressure in much of the northern Mediterranean basin is leading to establishment of dense pioneer forests exacerbating wildfire risk and a massive loss of species that require higher light levels as found under traditional grazing regime (Rolo *et al.*, 2019).

Better understanding the need for adaptation of Mediterranean trees and forests in the context of global environmental change and the modification of disturbance regimes is critical for a sustainable management of the Mediterranean forest landscape. Thus, efforts must focus on developing appropriate management practices and policies to secure the “option(s) of choice” for future generations.



Sites with observational/experimental data used in the paper by Peñuelas and Sardans. Source: Peñuelas, J.; Sardans, J. Global Change and Forest Disturbances in the Mediterranean Basin: Breakthroughs, KnowledgeGaps, and Recommendations. *Forests* 2021, 12, 603; <https://doi.org/10.3390/f12050603>



Key research questions identified:

- 1 How is climate change transforming forest structures, especially regarding changes in precipitation and increases in temperature and aridity?
- 2 What are the key elements of plant-soil interactions in relation to nutrient and carbon cycling under increasing aridity and leaching of nutrients?
- 3 How have tree morphology, physiology, growth, reproduction, and mortality responded to, or been influenced by climate-change impacts?
- 4 What is the role of Mediterranean forests in the creation of rainfall?
- 5 What integrated approaches to conservation and management can improve the resilience of forests including those involving microbes, fungi, lichens, and animals that are sensitive to the impacts of drought, fire, and other disturbances?
- 6 How do disturbances create or accelerate changes in forest ecosystems? What are the consequent effects on the economic and social functions of such shifts on species? How to build back better adapted ecosystems?
- 7 What management approaches help develop forest resilience without compromising their economic, social and biodiversity-related ecosystem services (e.g., approaches such as reforestation, afforestation, and livestock management)?
- 8 How might comprehensive land abandonment impact and promote key future changes for both ecosystems and local communities?



Suggested research approaches:

1

High-tech training modules (e.g., fire simulation exercises, virtual forest development, fuel management etc.) to assess the effects of disturbances on forest structure.

2

In-situ case studies to measure forest tree/shrub resilience under various drought conditions at various elevation zones.

3

Explore case impacts of disturbances on soil fertility, as well as socioeconomic effects on forest goods and services, and the post-disturbance costs of restoring infrastructure. Contrast with costs of risk-mitigation measures and their effectiveness.

4

Gleaning best practices from new community-based fire management approaches.

5

Modelling to project future forest conditions under various climate change scenarios.

6

Experiments to investigate the optimum intensity of livestock grazing in various Mediterranean forest ecosystems.

7

Using experience and modelling to predict specific forest stand conditions for rehabilitation with existing or new best-adapted genetic materials that provide the necessary ecosystem services (habitat, timber/fuel provision etc.).

8

Knowledge sharing and capacity building through training, coaching and skills transfer among Mediterranean institutions.



Opportunities

- The fossil energy crisis encourages the use of alternative energy sources, such as thinning residues, contributing at the same time to reducing wildfire risks.
- Managing Mediterranean forests for increased carbon sequestration and greenhouse gas emissions offsetting is increasingly needed.



Challenges

- Developing management strategies that avoid landscape homogenisation and excessive biomass / fuel accumulation.
- Slow evolution and update of the regulatory framework in different countries to be able to manage private and public forests following new recommendations.



Recommendations

- Feature controlled livestock management as a tool for maintaining biodiversity and mitigating wildfire risks.
- Implement hierarchical landscape planning at multiple scales by assessing the larger-scale drivers and effects of various disturbances and ecosystem services, while planning for minor-scale action such as improved stakeholder education and land management.
- Find synergies with biodiversity conservation and new circular bioeconomy activities when developing management strategies.

Theme 2: Conservation and management of biodiversity and forest genetic resources

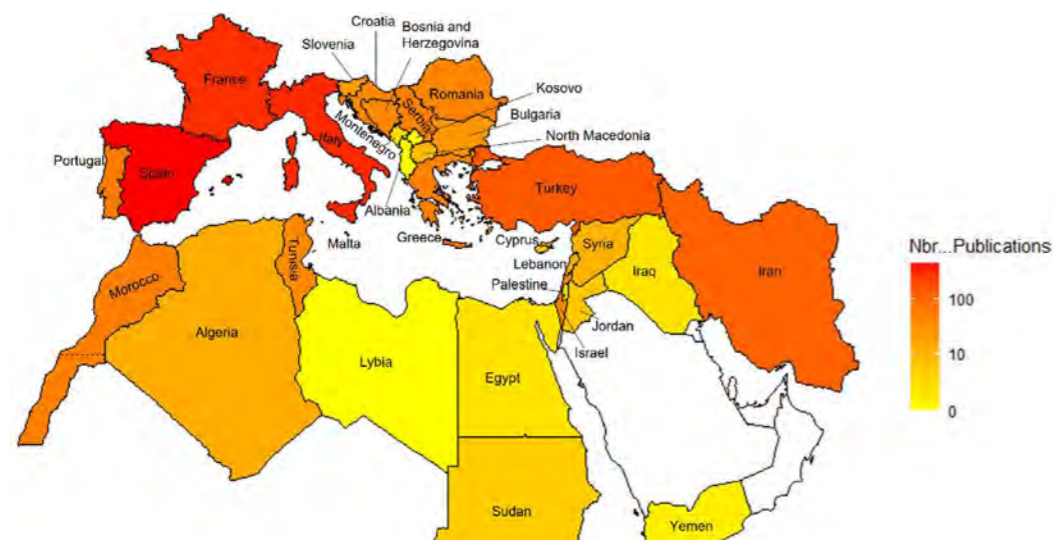
Numerous Mediterranean forest tree species are resilient to extreme and chronic droughts (Helman *et al.*, 2017). They are known to hold a high genetic diversity (see Fady 2005 for conifer species) that is increasingly recognised as a strategic pillar for biodiversity conservation and sustainable forest management.

To track their ecological niches under a changing climate, tree species are shifting their range northwards (Morin *et al.*, 2008) and to higher altitudes (Lucier *et al.*, 2009). Those that cannot adapt sufficiently fast will decrease in abundance or become extinct in part or all of their range (Fady *et al.*, 2016; Aurelle *et al.*, 2022). Management actions, such as maintenance of genetic diversity and assisted species migration are recommended (IPCC, 2014).

However, some important features influencing tree migration, such as tree dispersal mode, are not well understood. For example, the total dispersal kernel (TDK) describes the combined influence of all dispersal (biotic and abiotic) vectors affecting the dispersal, germination and establishment of a seedling. Their understanding is critically important for predicting plant responses to a changing biotic or abiotic environment and thus for tree migration (for review see Rogers *et al.*, 2019).

Forest biodiversity encompasses the multitude of plants, animals, fungi and microorganisms that inhabit forest areas and their associated genetic diversity. The whole community migration, including soil biodiversity, is essential for a successful establishment and should be taken into consideration (Vitali *et al.*, 2022).

The paper by Fady *et al.*, (2022) highlights the need for integrating currently compartmentalised forest genetic research. First, this means bridging a persistent geographical gap between genetic research carried out in different Mediterranean regions. Second, the challenge is to better link three dominant topical clusters: “Genetic diversity and differentiation”; “environmental conditions, growth and stress response”; and “species distribution patterns”.



Countries investigated for their scientific production in the field of forest genetics during the period 1991–2020. Source: Fady, B., Esposito, E., Abulaila, K. *et al.* Forest Genetics Research in the Mediterranean Basin: Bibliometric Analysis, Knowledge Gaps, and Perspectives. *Curr Forestry Rep* 8, 277–298 (2022). <https://doi.org/10.1007/s40725-022-00169-8>



Key research questions identified:

1

What is the potential of Mediterranean tree species to establish at northern latitudes?

2

How efficient is the natural dispersal ability of Mediterranean trees tracking their optimal conditions – with a focus on the total dispersal kernel for Mediterranean tree species and their associated community.

3

Will the disruption of key interactions between species lead to disruption of the entire interaction web and hinder whole-community adaptation and migration?

4

How should landscape-level management strategies (e.g., biodiversity corridors) be designed and implemented for lasting positive impacts on biodiversity at habitat, species and genetic levels?

5

What forest resource management approaches can be used to maintain and improve forest biodiversity and its resilience?

6

How can data and knowledge on forest biodiversity best be catalogued, archived and shared for effective habitat management?

7

What legal and policy limitations exist or need developing for effectively implementing and managing protected area networks (including genetic conservation units) across the Mediterranean region?

8

How do post-fire community dynamics influence adaptive potential and resilience within different forest types, and under different wildfire frequencies and intensities?



Suggested research approaches:

1

Build niche-modelling techniques based on trees' adaptive and functional traits and their distribution mode to forecast changes to species distributions under future climate scenarios and predict abrupt shifts of dominant tree species at different spatial scales during the next decades.

2

Apply population genomics to assess and monitor species interactions in reference forests and in restored forests (Breed et al., 2019). Meta-omics will elucidate any biological interactions before, during and after restoration activities. This helps more responsive and relevant planning for resilient restoration activities in the face of rapidly changing environments.

3

Transfer of best practices, ecosystem indicators, and effectiveness of conservation efforts, particularly for conservation projects aimed at safeguarding genetic diversity and adaptive potential.

4

Implement long-term ecosystem monitoring and experiments in protected areas as living laboratories for forest sustainable development.

5

Intensify observational, experimental and modelling research on tree species and within species mixtures, aiming at increased system productivity, stability and multifunctionality through trait-based mechanisms of complementarity and facilitation.

6

Gather a solid dataset (based on real data) affecting Mediterranean forests to be used in machine learning and similar statistical tools to predict future scenarios.

7

Develop and manage open-access databases and platforms for data and knowledge exchange in the field of forest genetics and biodiversity across the entire Mediterranean region.

8

Knowledge sharing and capacity building through training, coaching and skills transfer among Mediterranean institutions.



Opportunities

- Existing and emerging genomics tools such as population genomics and meta-omics can improve seed sourcing as well as the assessment and monitoring of restoration outcomes.
- The political context of ecological transition is favourable to biodiversity conservation and sustainable management (e.g., European Green Deal).



Challenges

- Genetic diversity in Mediterranean forest policy instruments and conservation efforts is not well integrated.
- The Mediterranean region is not an integrated political arena and human impact is high there.



Recommendations

- Functional trait, distribution and dispersal data often exist for Mediterranean trees only for their specific European locations. Extend data and analyses to include the whole Mediterranean region.
- Identify clear ecosystem indicators to measure conservation effectiveness, and adoption of these indicators across fields to allow for better standardised measures of effectiveness, and quantitative meta-analyses to identify best management practices.
- Identify and analyse the political and socio-economic settings that favour biodiversity conservation, including genetic diversity.

Theme 3: Forest management addressing trade-offs and synergies between multiple ecosystem services

Managing diverse ecosystem services implies both synergies and trade-offs; therefore, attempts to maximise just one or two services may lead to unanticipated losses in the provision of other services (Rodriguez *et al.*, 2006). Indeed, approaches that prioritise timber production are still dominant in much of Mediterranean forest management, despite the growing societal demand for multiple other services.

Based on their literature survey (for the last decade), Nocentini *et al.*, (2022) confirm a growing research interest in Mediterranean forest multifunctionality. Yet, “the ability of Mediterranean forests to provide all these benefits is increasingly being challenged by environmental and social changes” (*ibid.*).

Among other ecosystem services, the hydrological services provided by forests are being broadly recognised as important (Biot *et al.*, 2011; Muys *et al.*, 2014). However, they remain poorly understood at more complex scales. The consequence is that green water-related services provided by forests (services related to the forest’s capacity to evaporate water, like erosion control and rainfall creation) continue to be undervalued in comparison to blue water-related services (water recharge in rivers and aquifers) (*cf.* Ellison *et al.*, 2017; Muys *et al.*, 2021).

On the other hand, cultural and health services are lagging even further behind, though increasing attention is given to non-wood forest products – a traditional productive activity across the Mediterranean – such as cork, pine nuts, or fungi (Wolfslehner *et al.*, 2019). Many Mediterranean landscapes have been shaped by human-environment interactions over centuries (Gauquelin, 2018). Yet, climate-change-induced disturbances such as increasing aridity and occurrence of megafires, or anthropogenic alterations in stand structure and density such as overgrazing or land abandonment, are key drivers of change in the bundles of products and services that Mediterranean forests provide (Nocentini *et al.*, 2022).

Mediterranean forests as part of a landscape mosaic of uses should be maintained not only for their cultural and historical importance, but also because they can contribute to keeping options open for adaptation to global change.

Both research and policymakers should contribute to finding sustainable solutions for maintaining economically and environmentally viable livelihoods in these precious environments (Nocentini *et al.*, 2022). One of four policy pathways for future EU forest policy to support ecosystem services provision (Winkel *et al.*, 2022), an EU-wide payments for ecosystem services (PES) system holds significant potential to advance the provision of forest ecosystem services (FES). However, some FES, such as watershed protection, are more locally rooted – and may thus also be better addressed through locally or nationally conceived incentive systems.



Key research questions identified:

- 1 What risks and opportunities will large-scale Mediterranean landscape transformations present, and how can multifunctional forest management adapt to respond to them?
- 2 What new multifunctional forest management approaches are required to support multiple ecosystem services as an alternative to narrower approaches commonly used for wood production?
- 3 How can previously understudied ecosystem services, such as cultural and hydrological forest functions, best be identified, quantified, and valued?
- 4 Which Decision-Support System (DSS) will be most relevant to multifunctional forest management in the Mediterranean? And how can we best integrate various aspects of the climate-change issues (mitigation and adaptation) in its design?
- 5 How can current advances in the availability of accurate, high-resolution spatial data help in estimating more precisely the provision of multiple ecosystem services?
- 6 How can land abandonment both positively and negatively impact biodiversity, ecosystems and local communities and the services that forests provide?
- 7 What approach of vegetation management can help spare human-related activities and human lives in case of wildfires?
- 8 How might bioeconomy-related policies and strategies influence the design and implementation of multifunctional forest-management planning processes?



Suggested research approaches:

1

Design innovative multi-objective forest management models for researchers and practitioners to help customise design and implementation of appropriate management prescriptions.

2

Adopt an overall approach of vegetation / fuel load management at the landscape level beyond forest boundaries.

3

Develop versatile DSS to i) address risks and uncertainties; ii) help achieve multi-faceted forest-management goals; and iii) analyse synergies and trade-offs between various ecosystem services, focusing on the water-fire-biodiversity nexus.

4

Deploy DSS to develop management approaches that accommodate bioeconomic policies and strategies.

5

Develop and implement management alternatives and multi-stakeholder engagement strategies (market, state, community) that will ensure sustainable production of multiple ecosystem services under climate change constraints.

6

Explore to what extent do the public understand the importance of multiple ecosystem services and value them and how do these perceptions have impacts on public expectations and preferences among several forest landscape management approaches.

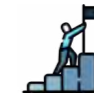
7

Knowledge sharing and capacity building through training, coaching and skills transfer among Mediterranean institutions.



Opportunities

- Increasing need for interactions of highly urbanised societies with nature for recreation, health and wellbeing.
- The increasing integration of economic tools and approaches into nature conservation efforts.



Challenges

- Managing forest ecosystems for multiple ecosystem services (functions and benefits) in the long term requires a transdisciplinary approach.
- Absence of standardised Mediterranean forests inventories.



Recommendations

- Sustainable solutions for maintaining economically and environmentally viable livelihoods in traditional Mediterranean forest landscapes should respect cultural and historical importance, contribute to biodiversity conservation, and offer adaptive potential for future climate and other global changes (Muys et al., 2022).
- Further research should pay greater attention to Southern and Eastern Mediterranean countries, where the multiple pathways of land abandonment are emerging.
- Mediterranean forest inventories should be expanded beyond forest production-related indicators and be standardised to establish a spatial database, providing the necessary data for multifunctional forest-management planning.

Theme 4: Social and business innovations and policy instruments supporting the Mediterranean forest-based bioeconomy

The Mediterranean forest bioeconomy captured by the market represents only part of the benefits provided by forests: over 65% of the total economic value of Mediterranean forests comes from non-wood forest products and ecosystem services (Merlo and Croitoru, 2005). Yet, most of this value remains outside traditional markets, and does not flow to the forest owners and managers whose land-use decisions affect their provision (Martinez de Arano *et al.*, 2018).

Beyond specific markets (e.g. cork, poplar or resin) or niche markets (e.g. green-oriented bioproducts), Mediterranean forest industries have so far displayed limited technological advancement, are based on imported wood resources, and deal with fragmented and de-structured value chains (Nilsson 2007). Additional challenges arise from peculiar characteristics of Mediterranean forests: i) the high cost of forestry activities, due to their rough mountainous topography, their remoteness and low accessibility; and ii) the changing attitudes, needs and capacities of forest owners.

Payments for ecosystem services (PES) offer interesting opportunities for activating forest conservation and good management, by complementing the limited revenues from marketable products with rewards from synergetic ecosystem services (e.g., wildfire risk reduction or watershed protection).

Social innovation in forestry includes new ways of actors' interactions, values and governance arrangements. By engaging citizens in tackling societal challenges, social innovation initiatives contribute to any of: i) strengthening the wellbeing of rural communities; ii) meeting social demands (e.g. on ecosystem services); iii) catalysing and gearing value-chain actors towards more dynamic markets; and iv) making the forestry sector more inclusive. Such social engagement helps gearing the socio-ecological-economic components of the system to achieve more resilient territories.

The paper by Secco *et al.*, (forthcoming) highlights that most Mediterranean scientific publications focus on technological innovations, while social innovations are incipiently emerging, and organisational and institutional innovations are almost disregarded. Yet, the increased recent importance of social innovation research, with European research and innovation funding programmes promotes the role of human and social capital and societal engagement.



Key research questions identified:

- 1 What are the barriers for innovation adoption and social, technical or institutional/business entrepreneurship in Mediterranean forests and how to overcome them?
- 2 What types of innovation and what innovation systems would help support more resilient forests and forest-related communities in the Mediterranean region?
- 3 What opportunities do Mediterranean forests offer for innovative substitutions of Greenhouse gas emissions-rich materials and processes? Which innovative mechanisms would allow for internalising currently non-marketised ecosystem services?
- 4 What does it take for more PES initiatives to emerge, thrive, and deliver high-level impacts?
- 5 How can scientists, policymakers and other stakeholders better translate real-time needs and challenges into effective innovation processes?
- 6 What communication and knowledge transfer approaches between scientists, policymakers, and practitioners might serve/improve the development pathways of innovation in Mediterranean forestry?
- 7 How can the playing field be levelled so that social, institutional and organisational innovations, backed up by social science research, receive the same levels of support as natural/physical sciences and technology?



Suggested research approaches:

1

Adopt transformative transdisciplinary research approaches and tools that reciprocally engage scientists and other stakeholders.

2

Design, test and apply systems thinking/system dynamics frameworks to analyse complex socio-ecological-institutional systems for the development of a Mediterranean forest bioeconomy and required innovations.

3

Combine quantitative and qualitative approaches and tools, and triangulate data to monitor and evaluate innovation and policy effectiveness, and design and use appropriate visualisations (see “research weaving” - Nakagawa et al., 2019) to communicate results.

4

Exploit forest-science knowledge through co-creation processes to bolster social innovation processes, for example by adopting creative methods and appreciative inquiry techniques, emphasising solutions, and stimulating citizen proactivity by empowering actors.

5

Case-comparative analysis of pilot PES initiatives and their outcomes, as of failed efforts to establish PES at different scales.

6

Focus on needs-driven research rather than interest-driven topics when developing the research agenda.

7

Knowledge sharing and capacity building through training, coaching and skills transfer among Mediterranean institutions.



Opportunities

- An increasing interest in the topic due to rising global demand to provide sustainable alternatives for technologies and products, as well as adjustments to the consumption and waste generation patterns.
- Examples of success stories where social and business innovations in the domain of forest-based bioeconomy turned into viable flourishing businesses.



Challenges

- Knowledge transfer to policymakers and practitioners is critical for transforming scientific research into an innovation actions that are supported, accepted, and used by actors.
- Funding for innovation focuses on technology meaning there is a lack of stable and long-term funds, resources and institutional efforts for transdisciplinary research, and innovative social-political-governance actions.



Recommendations

- The novelty and innovation of research and development in the Mediterranean can be enhanced by i) using a multidisciplinary approach, from natural to social sciences; ii) using holistic governance frameworks; iii) motivating private investors, businesses and entrepreneurs to participate; and iv) integrating various types of knowledge and innovation (technological, organisational, social and institutional).
- Frugal and small-scale innovations need support. These are based on key factors other than large financial capital and industrial investments, which are more appropriate to Mediterranean peculiarities. These factors include: i) social capital; ii) trust towards institutions; iii) site-specific nature-based solutions designed, implemented and monitored by local networks; iv) niche markets; and v) interdependencies between forest and other systems (e.g., tourism, local development, health, education, finance, food security).
- Criteria for evaluating scientists/researchers performance needs modification, and science-stakeholder-policy efforts need to be weighted in a similar way to scientific publications to encourage knowledge transfer from science to policy and practice.

4. Implementation

Developed with input from academia, industry, governmental and non-governmental collaborators, MFRA 2030 is a call to the research community to fill forest research and knowledge gaps and to ensure that forest policymakers and practitioners are guided by science in their decision-making.

The MFRA 2030 articulates the research needs for effective Mediterranean forest management for the next eight years. However, some urgent priorities should be defined for immediate action. These research priorities require adequate and consistent funding, political support, public administration capacity, public-private entrepreneurial interaction and well-framed research concepts.

This nexus of conditions is particularly important because of political disparities across the Mediterranean and of its fragmented context of land ownership, stakeholders, communities and ecosystems.

Mediterranean forest research progress will also depend on the individual and collective research potential of all Mediterranean countries. It will also depend on overcoming unequal resource distribution and infrastructures. Specifically, Mediterranean forest management and forest-related innovation and policy research should build on long-term research partnerships and networking that apply participatory research and develop junior research capacity.

Similarly as for MFRA 2020, the implementation of MFRA 2030 will continue to build a Mediterranean forestry knowledge triangle of research, education and innovation, based on its geographic triangle with vertices in **Mediterranean Europe**, **Eastern** and **Southern Mediterranean** regions.



Source: EFIMED / In-house production

Coordination and networking

MFRA implementation requires extensive efforts in networking and coordinating research and will require a coordinated effort by the research community and related stakeholders (see **Box I**).

EFIMED plays a pivotal role in coordinating the efforts of the Mediterranean research body, providing networking opportunities, building solid consortia and helping in developing funding proposals.

The Mediterranean forest community meets regularly during the biennial editions of EFI Mediterranean Network

Forum, launched in 2022 to mark the launch of this agenda, and Mediterranean Forest Week. In parallel to those events, a follow up committee with scientists and stakeholders whose composition reflect the diversity of partners, will be created and will meet regularly to monitor the implementation and revise the priorities of the Agenda on a bi-annual basis.

Formal and informal education

For the implementation of the MFRA 2030, the support of the education system is crucial. It will be vital to ensure that curricula in universities and training institutions are aligned with the MFRA 2030 in tackling Mediterranean forest management issues and associated challenges. Advocating for similar alignment on key messages in school curricula is essential for a long-term societal shift in accepting forest management practices for Mediterranean forest resilience. Collaborative work with policymakers, educationalists and civil society organisations is fundamental in this regard.

MFRA 2030 encourages the support of training opportunities and short-term scientific visits among participating countries providing capacity building and technical assistance and sharing of good practices and expertise. EFIMED will work with collaborating institutions to organise regular Young Leadership Programmes and offer grants to support the Mediterranean youth.

Funding the MFRA 2030 implementation

The implementation of the MFRA 2030 must be underpinned by sustainable institutionalised financial support. EFIMED will work with relevant institutions and organisations to identify funding opportunities and reach out to donors to communicate MFRA priorities and generate funding opportunities.

Box I.

Mediterranean stakeholders

National research institutes, universities, regional research groups, international research organisations, nongovernmental organisations, industries, local municipalities and territorial entities.	Foresters, farmers, policymakers, decision-makers, civil society organisations, and grassroots organisations (forest owners, cooperatives, youth groups, volunteers in action when there is a forest-related emergency).
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A few urgent Mediterranean forest challenges may be addressed by individual countries alone. But most challenges can be addressed, and their negative consequences avoided more rapidly and effectively, if concerted actions are undertaken. Wicked, supra-national and large-scale problems can only be tackled with a transnational systems-based, holistic, and collaborative approach. While the Mediterranean region's diversity is currently expressed by high levels of political, economic, and social fragmentation, it also boasts a reservoir of opportunities, especially in the environmental sector. If managed well, the region's diversity could equally become a source of complementarities, growth and development that MRFA-linked stakeholders have yet to more comprehensively harness.



Photo: Pexels

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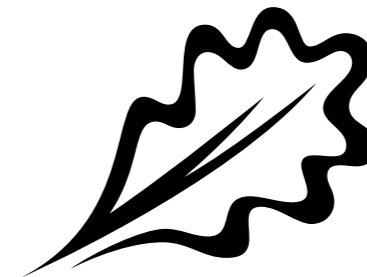


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