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LIFE MIXFORCHANGE

**INNOVATIVE MANAGEMENT
STRATEGIES FOR ADAPTING
MIXED SUB-HUMID
MEDITERRANEAN FORESTS TO
CLIMATE CHANGE (2016-2022)**

Layman report

The context: the challenges of sub-humid Mediterranean forests



Sub-humid Mediterranean forests are an ecosystem of great uniqueness and importance at a European level. In Spain, these forests are mainly located in pre-coastal mountain ranges in the northeast (Barcelona and Girona provinces) and the central south (Cadiz and Málaga provinces).

This type of forest is often a mixed forest (that is, with two or more tree species mixed) with a significant presence of deciduous or broadleaf trees. Some of the most representative species of this forest include holm oak (*Quercus ilex sbsp. ilex*), oak (*Quercus pubescens*, *Q. petraea*, *Q. canariensis*), chestnut (*Castanea sativa*), pine (*Pinus sylvestris*, *P. pinea*, *P. pinaster*), wild cherry (*Prunus avium*), cork oak (*Quercus suber*), maple (*Acer pseudoplatanus*, *A. opalus*, *A. campestre*), ash (*Fraxinus angustifolia*, *F. excelsior*) or sorb tree (*Sorbus domestica*, *S. torminalis*).

The climate is characterized by mild temperatures and high rainfall, resulting in high productivity. In addition, many of these forests have a peri-urban character, that is, they are located around towns or cities. These factors make these ecosystems particularly relevant in terms of **ecosystem services** provision: support (biodiversity, soil formation), provisioning (production of renewable biological resources: timber products, mushrooms, cork, pine nuts, medicinal plants), regulating (water and nutrient cycling, soil protection, carbon sequestration, protection against extreme temperatures and storms) and cultural (landscape, leisure and educational activities).

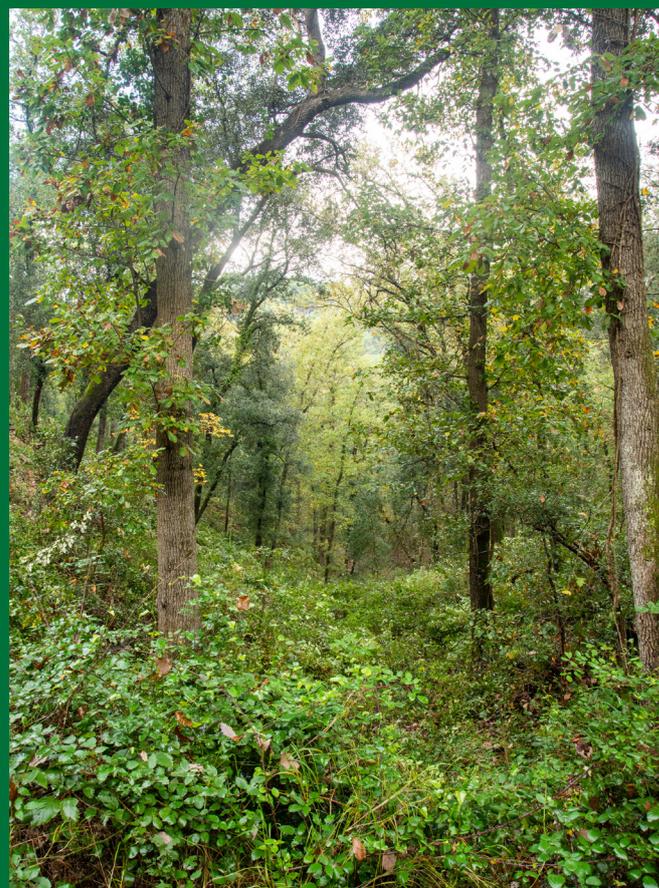
These forests of great environmental, productive and social interest are subject to threats that jeopardize the provision of many of these ecosystem services. The main threats are associated with climate change, as shown below.



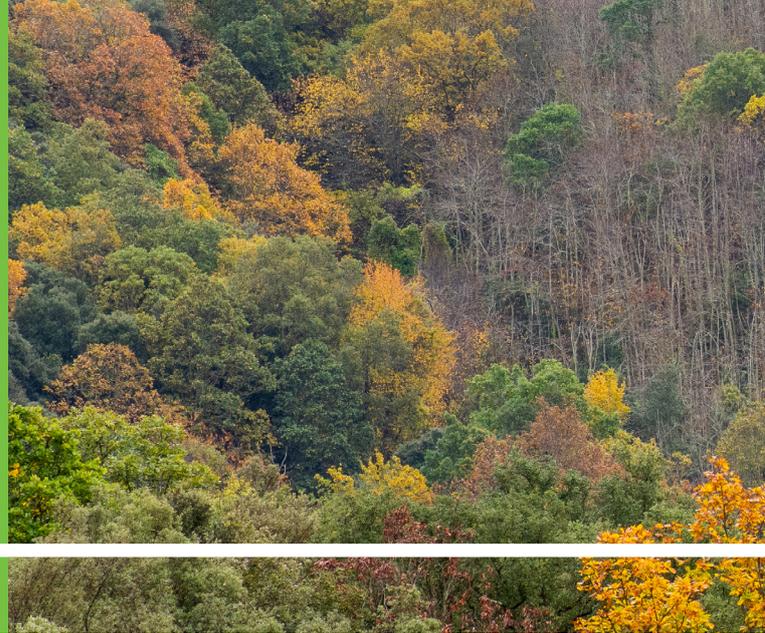


These threats are exacerbated by some specific characteristics of these forests:

- many of these species are poorly adapted to drought and fires.
- a significant portion of the forested area has been abandoned (unmanaged) for decades, often presenting problems of excessive density and low vitality. The reasons for this abandonment are many and include the low price of forest products and high labour costs, small property sizes, the weakening link between ownership and their forests and the lack of incentives.
- applied silviculture is often very simplistic, focused on a single product, often with low added value and a short value chain (mainly firewood or splinters).
- lack of public and political awareness on the importance of maintaining the vitality of these stands through active, sustainable and multifunctional forest management.



The LIFE MixForChange project, summed up



Goals

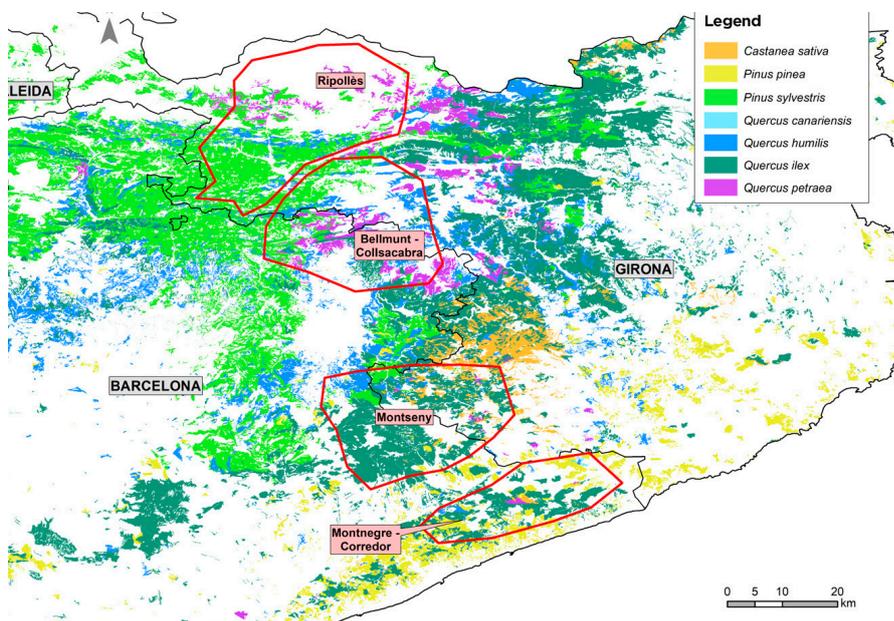
The main objective of the project is to contribute to the adaptation and greater resilience of mixed sub-humid Mediterranean forests to climate change, favouring their conservation and the maintenance of their productive, environmental and social functions. Specifically, the project aims to:

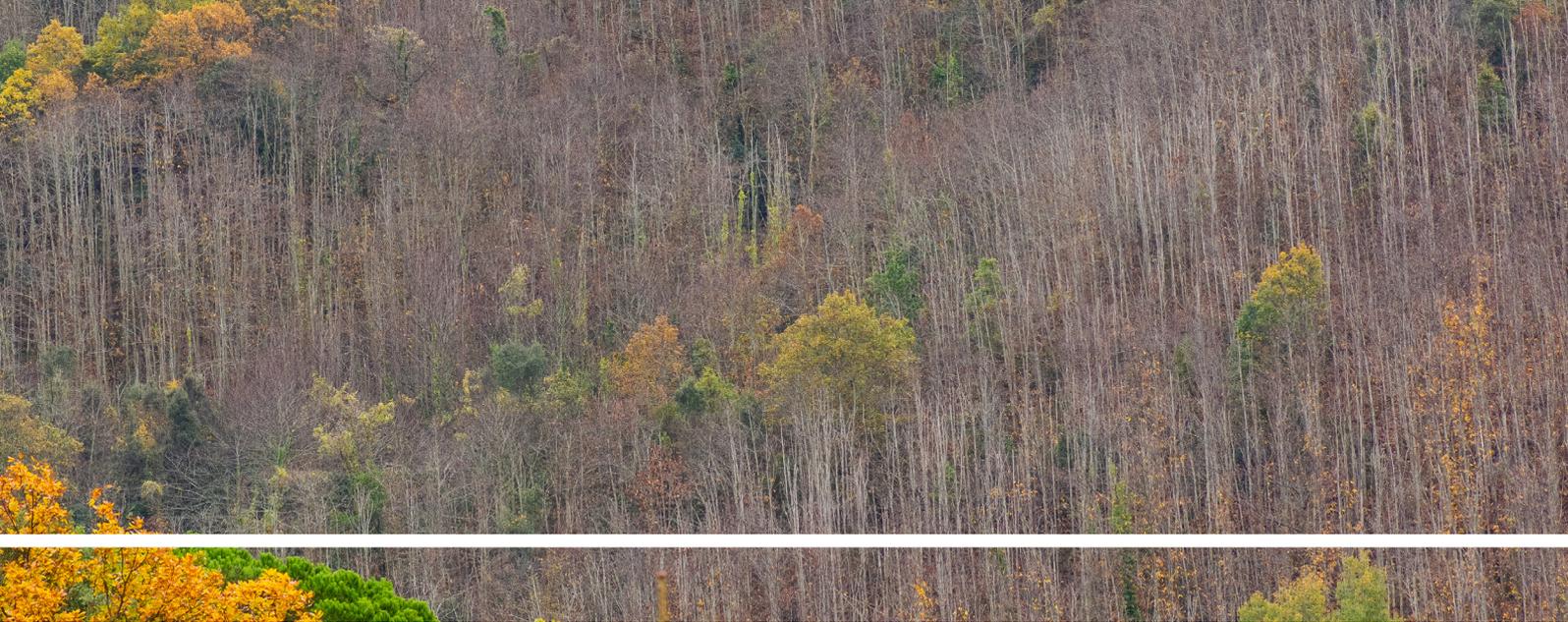
- Develop and implement innovative forest management techniques, which allow forests to adapt to climate change and improve ecological and economic value in the medium term.
- Develop new tools to integrate the adaptation of sub-humid Mediterranean forests to climate change into the policy and laws on forest management.
- Develop new tools to strengthen the economy linked to the products provided by these forests, preventing or reversing their abandonment.

- Transfer the tools and techniques developed and results obtained taking into account the main stakeholders (forest owners, technical staff and public administration) at a regional, national and European level, and raise social awareness on the challenge of adapting forests to climate change.

MixForChange forests and pilot sites

The silviculture method developed during the project has been applied on 164 ha of mixed sub-humid Mediterranean forests: holm oak forests, chestnut forests, oak forests and pine forests, in four geographical areas in Catalonia (northeast Spain).





Beneficiaries

The beneficiaries of the project are four complementary entities.



Forest Science and
Technology Centre of
Catalonia (*coordinator*)



Forest Ownership Centre



Forest Owners'
Association Montnegre
i el Corredor



Forest Owners'
Association Bellmunt
Collsacabra

In addition, Barcelona Province Council participates as a collaborating entity.



**Diputació
Barcelona**



MixForChange Silviculture: how to adapt forests to climate change with environmentally and economically sustainable silviculture

We have developed an innovative silviculture method based on:

- ORGEST (Regional guidelines and silvicultural models for sustainable forest management in Catalonia)
- Climate change adaptation criteria
- Multifunctional approach
- Close-to-nature silviculture
- Single-tree silviculture

These criteria are specified by:

→ Reducing competition for water and light between trees to enhance their vitality. This is achieved by **thinning**, that is, cutting down some selected trees.

Thinning has the following characteristics:

- Detailed: cutting the trees that compete more intensely with the ones that are most useful from the point of view of economics (well-formed trees of valuable timber species) or conservation (underrepresented species, trees with microhabitats for wildlife, such as cavities or deep cracks in the bark) → it increases vitality globally, and especially for the most valuable trees.
- Selective: cutting down diseased trees, low-vigour trees and trees of especially abundant species and sizes → diversity of species and sizes is maintained, with an increase in heterogeneity.
- Low intensity: no more than 25-30% of the wood volume is cut → this maintains a dark and humid “microclimate” inside the forest, which makes it possible to limit the loss of moisture from the soil and wind while limiting the future development of the undergrowth.



→ Reducing competition for water between the undergrowth and trees, to enhance their vitality and reduce the vulnerability of forests to large fires. This is accomplished through the **selective understorey clearing**. Clearing has the following characteristics:

- Detailed: cutting brush over 1.3 m high to break vertical continuity of fuel, that is, to reduce the risk of brush fire going into canopies.
- Selective: maintaining all present species of brush, but cutting the most abundant and highly flammable brush species, with little use for wildlife (e.g. not producing edible fruits), more intensely.
- Moderate intensity: maintenance of about 25% of undergrowth cover, due to the role it plays from a biodiversity point of view.

Finally, the debris from these tasks are chopped up to reduce vulnerability to forest fires.



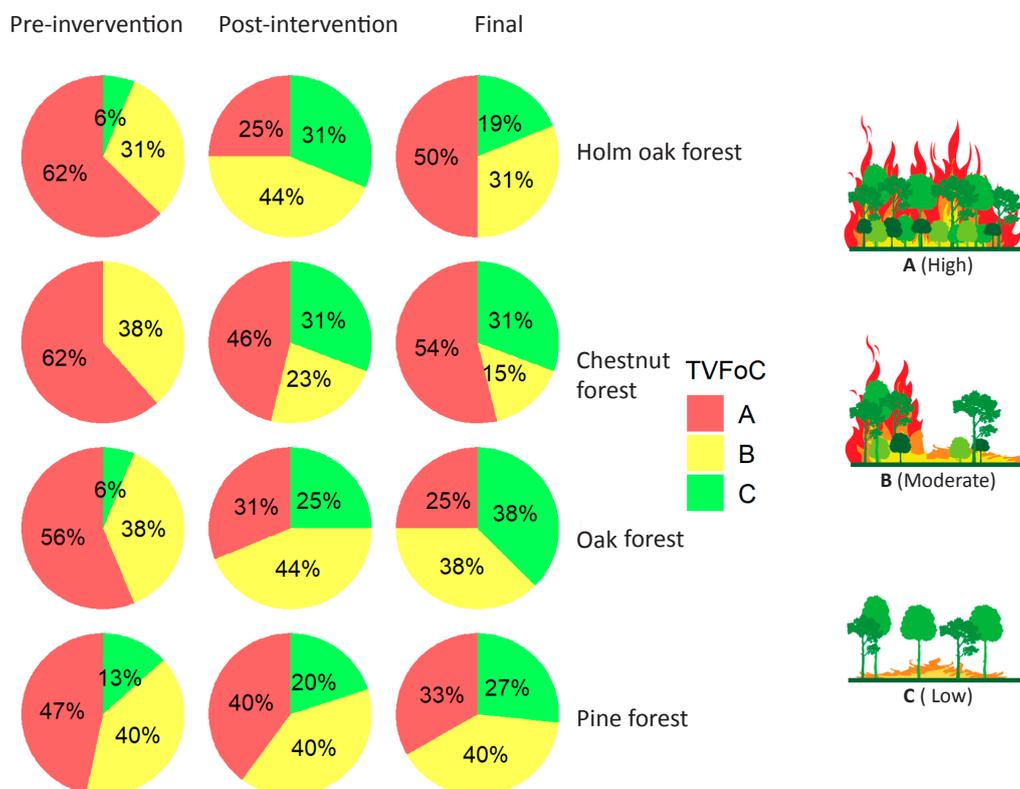
What are the results of MixForChange silviculture? (I)



Before and after the innovative silviculture interventions, different variables were monitored in detail to characterize their effects on the most relevant ecosystem services and economy indicators. We studied the effect of treatments compared to the initial state of the forest, to untreated parts of the forest or to the application of conventional forest management, that is, the management type routinely applied to each work area of the project.

Adaptation to climate change: effect on vulnerability to wildfires

We have studied the evolution of structural vulnerability to crown fire (TVFoC, Piqué *et al.*, 2011), an indicator of the risk that in the event of fire, it reaches the forest canopy and, thus, propagates virulently becoming a Large Wildfire.



The silviculture applied aims to create complex forest structures, which would not be the optimal ones in the framework of a silviculture primarily focused on fire prevention. In spite of this, the silviculture actions (“post-intervention”) have significantly reduced the vulnerability to forest fires with respect to the initial situation (“pre-intervention”). After two or three years (“final”), oak and pine forests have continued to reduce their vulnerability to fires as the cutting debris settle.

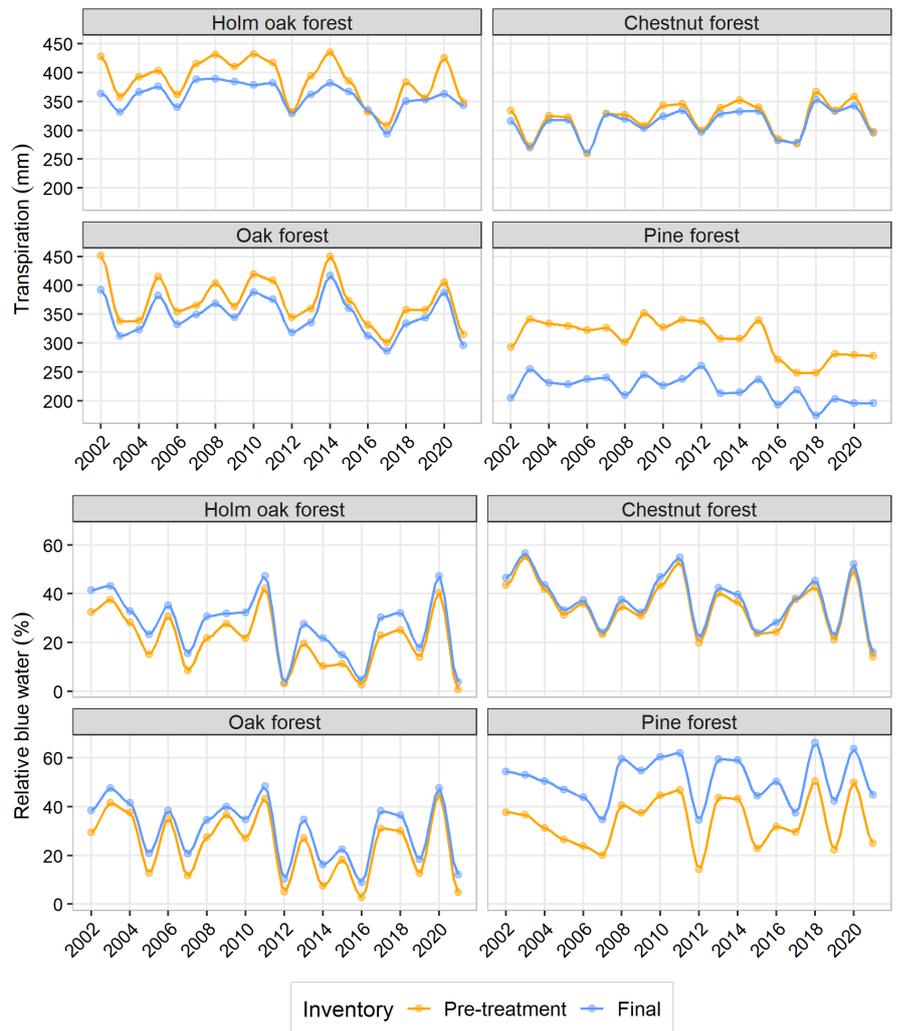
Adaptation to climate change: water balance and soil moisture

Water availability is the main limiting factor for plant growth in the Mediterranean, and this resource is expected to become increasingly scarce. Forests play a key role in the water cycle, improving water quality and regulating water flows.

Water balance of MixForChange silviculture

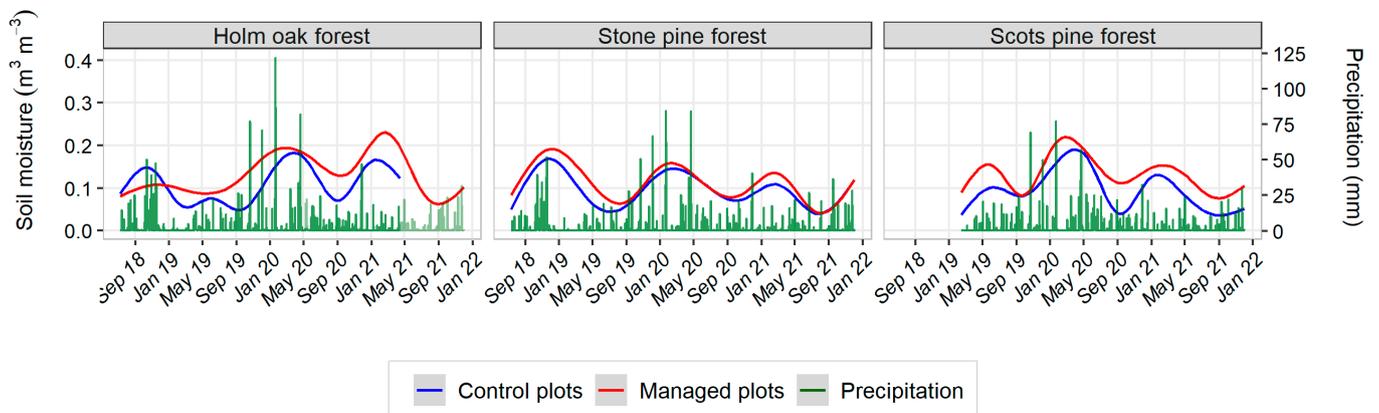
We studied the effect of the applied silviculture on transpiration (the water used by the forest to grow) and relative blue water (the percentage of precipitation that passes through the forest and reaches watercourses) in several MixForChange stands, using the *Medfate* model (De Cáceres et al., 2021).

By reducing tree density and understorey cover, the project's silvicultural interventions reduce transpiration, especially in holm oak and chestnut forests, and increase relative blue water, especially in pine forests. Therefore, the applied silviculture improves the water balance and increases the available water.

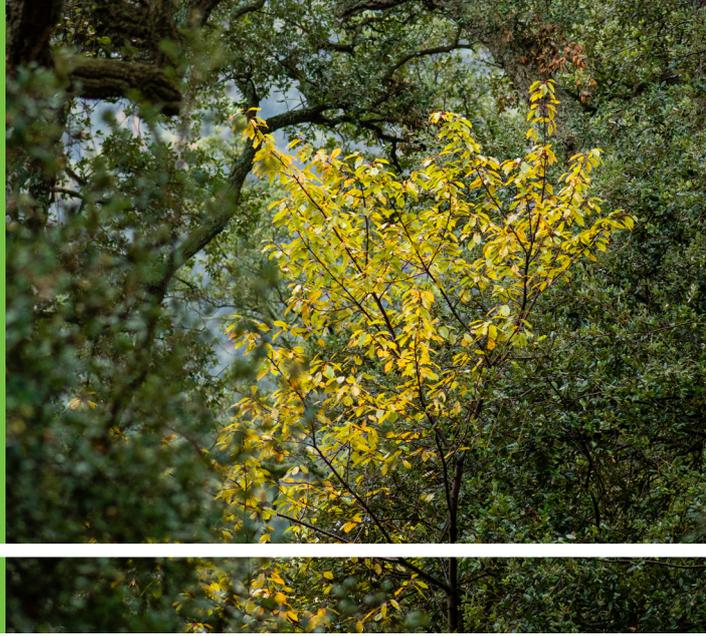


Soil moisture

We installed a series of soil moisture sensors on monitoring plots treated with MixForChange silviculture ("intervention") and on untreated ("control") plots. We observed that the silvicultural treatment generally leads to an increase in soil moisture in holm oak and in the two types of pine forest.

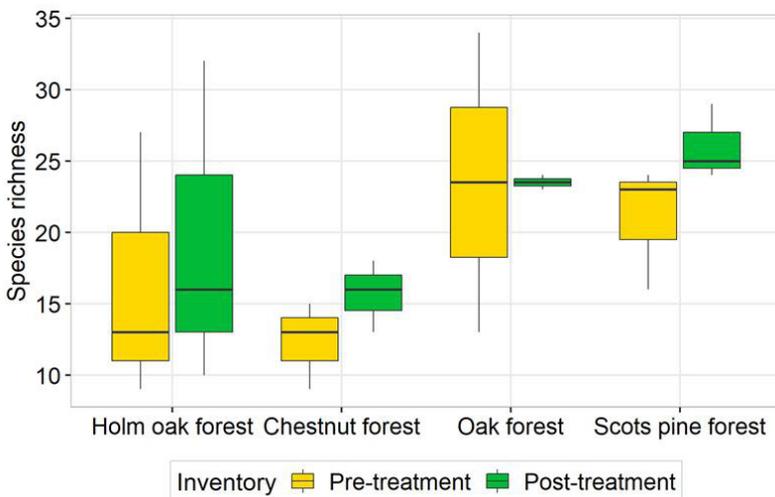


What are the results of MixForChange silviculture? (II)



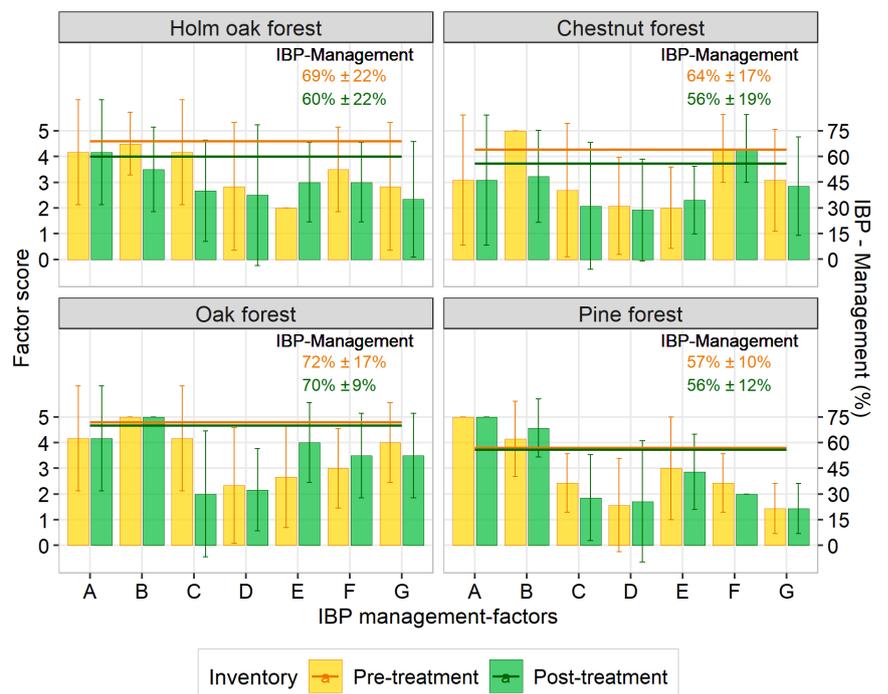
Effects on biodiversity

Biodiversity has been assessed with two indicators: floristic richness (total number of plant species) and potential capacity to host biodiversity, expressed with the Potential Biodiversity Index (version by Baiges *et al.*, 2019)



Comparing the floristic richness of plots before (“pre-intervention”) and after (“post-intervention”) the innovative silviculture application, we observe that all the present species were maintained, with punctual increases. This situation has occurred for trees, shrubs and grasses (data not shown).

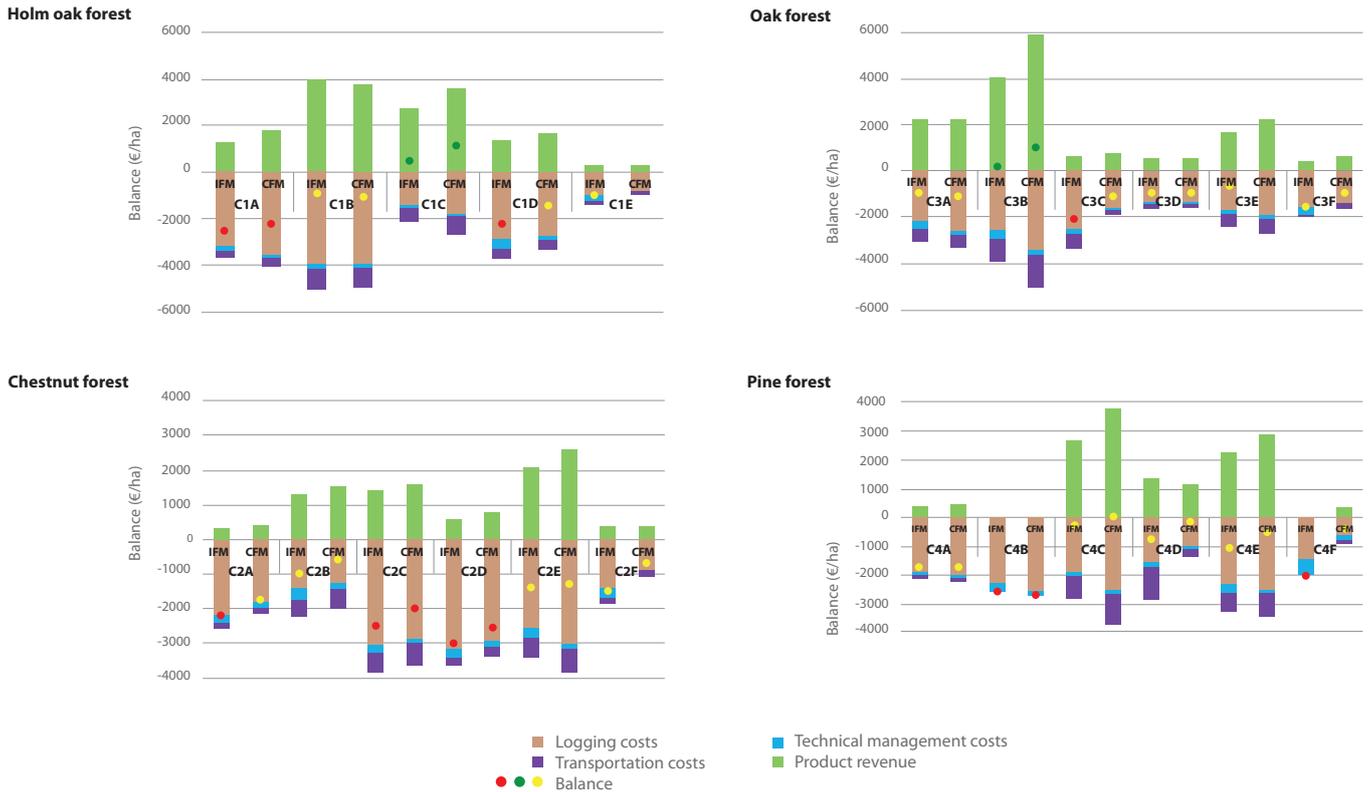
The Potential Biodiversity Index, a tool that estimates the capacity of a forest ecosystem to host biodiversity, has been applied on a pilot scale. The silviculture applied was not intended to directly increase biodiversity, but it can be observed that the PBI value remains stable with the application of silviculture (oak and pine forests) or shows a slight decrease (holm oak and chestnut forests). In any case, the PBI is a tool for assessing the effect of silviculture in the medium and long term.



Effect on the economic balance

We studied, mainly by surveys, the costs and revenues of innovative silviculture interventions compared to conventional silviculture, in order to evaluate the economic balance of both alternatives.

Both MixForChange and conventional silviculture present a negative balance for all types of forests, with average values between -600 and -1,800 €/ha. The economic results for MixForChange silviculture have been similar to those of conventional silviculture in forests with higher accumulation of intermediate and large trees. In contrast, in forests with smaller trees, the economic balance has been more negative in the case of MixForChange silviculture. MixForChange silviculture has lower income values (due to the extraction of less product) and higher costs of technical staff (tree selection, workers training) and understorey clearing (more selective) than conventional forest management. On the other hand, cutting and extraction costs are lower in MixForChange silviculture.



Economic balance of the application of conventional forest management (CFM) and innovative or “MixForChange” management (IFM) in different types of forests, in representative Montenegro-Corredor stands. The dots in each column indicate the economic balance of the intervention: positive (green dot), negative up to -2,000 €/ha (yellow) and below -2,000 €/ha (red).

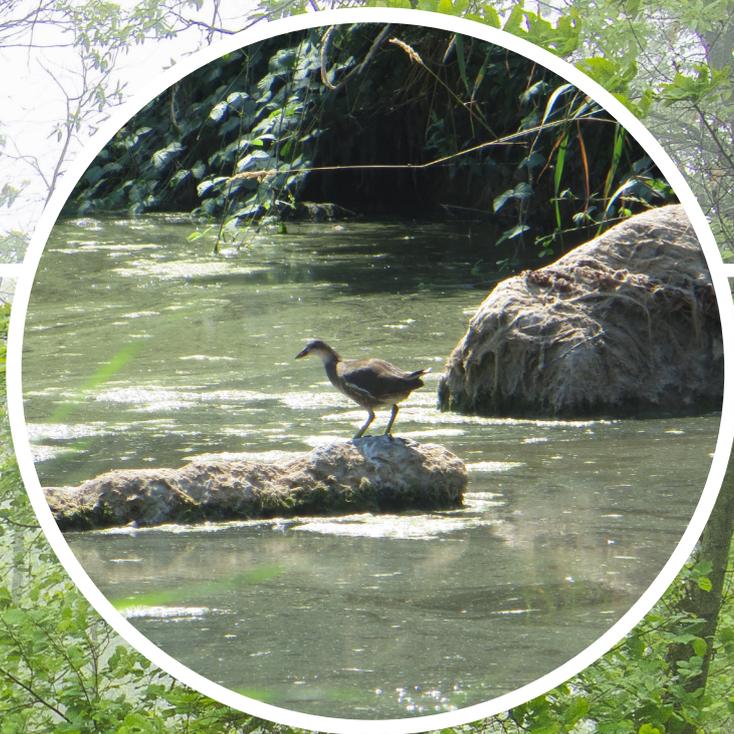
It should be said that these results correspond to a first application of this silviculture in masses that underwent decades without management, or subject to conventional management. The economic results of this innovative silviculture are expected to become more favourable as it is applied with the same criteria in the future, the forest workers are more familiar with these principles and a growing share of high-quality timber is produced.

Conclusions after applying MixForChange silviculture

We have shown how this type of silviculture presents, in the short term, important advantages from an adaptation, environmental, social and economic point of view:

- **Adaptation to climate change:** MixForChange silviculture has demonstrated its usefulness in reducing the competence and improving tree vitality and growth. Moreover, it reduced the vulnerability to large forest fires and improved the water balance, without affecting floristic richness or the biodiversity hosting capacity.
- **Environmental:** the usefulness of MixForChange silviculture in biodiversity conservation is due to the low intensity and high selectivity of the interventions, and the incorporation of specific conservation criteria: promoting scarce species, maintaining trees with singularities for fauna (microhabitats, standing deadwood or deadwood on the ground) and fruit-bearing shrubs and flora with special interest.
- **Social:** while adaptable to a wide variety of contexts, MixForChange silviculture is especially promising for peri-urban environments and highly frequented areas, where society may be sensitive to more intense silvicultural interventions. In addition, the good environmental results make this form of silviculture likely to be seen as an interesting alternative in the face of these forests' abandonment.
- **Economical:** the repeated application of this silviculture is expected to create forests with a growing presence of high-value trees and a decreasing cost of interventions (pruning, tree cutting and extraction) in comparison with conventional management.





Actions to improve management of Mediterranean forests



We have developed a series of actions aimed at promoting the adoption of the silvicultural principles developed in the project in new areas and forests.

Adaptive and close-to-nature management in mixed sub-humid Mediterranean forests (2022)

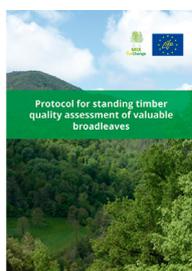


The aim of this [technical manual](#) is to assist decision-making in mixed sub-humid Mediterranean forest management, incorporating climate change adaptation and close-to-nature silviculture criteria.

The publication is structured in four blocks:

- Introduction to the Mediterranean forest, climate change and the adaptive and close-to-nature silviculture of mixed forests.
- Description of silviculture applied in MixForChange project: general principles, description of the interventions for holm oak, chestnut, oak and pine forests and practical lessons learned during the implementation of the treatments.
- Valuation of applied silviculture: effects on adaptation indicators (vitality, biodiversity, water balance, vulnerability to fire), climate change mitigation (carbon sequestration) and economic balance.
- Challenges and legal measures to promote the implementation of an adaptive, close-to-nature and multifunctional silviculture.

Protocol for standing timber quality assessment of valuable broadleaf species (2020)



This [Protocol](#) facilitates the assessment of the quality of standing timber and the potential industrial uses of the main high-value broadleaf species, in particular oak, ash, maple, cherry and chestnut, although it is applicable to other species (e.g. rowan, pear, walnut). It is a tool to quickly assess the potential of a tree at different vital stages to generate quality timber. The aim is to facilitate the design of the most appropriate silvicultural interventions to generate high-value timber products.

Replication actions

In addition to the 164 ha of demonstrative treatments, a total of 56 ha in 10 stands located in NP Montnegre-Corredor, NP Montseny and NP Montesquiu were replicated following MixForChange principles, with support from the project partners. This support included stand characterisation, treatment design, training in tree marking and logistical support. This action has allowed knowledge to be transferred to various stakeholders, including forest works companies, forest owners and practitioners from both public and private entities.





Training and capacity building actions

During the project we carried out the following specialized training activities:

- Three specialization courses on the application of adaptive silviculture based on MixForChange criteria, aimed at forest engineering students of the University of Lleida (November 2019) and forest managers (September and October 2021).
- Six days of technical transfer for forest managers, including owners and practitioners from public and private entities.

In addition, in all the intervened forests (both pilot sites and replication areas), the principles of this silviculture have been transferred directly to the owners, to forest managers and also to the forestry companies.



Technical articles and communications in congresses

Throughout the project we have prepared eleven articles in technical journals and issued eight communications in congresses and seminars.



Ecological, dasometric and socioeconomic assessment methodology

We have developed a methodology to evaluate the effect of MixForChange silviculture on a wide variety of climate change adaptation and other ecosystem service indicators, applied in a network of 85 long-term inventory plots.



Actions to strengthen the bioeconomy and governance of sub-humid Mediterranean forests



The main actions (shown below) aimed to strengthen bioeconomy (i.e., economic opportunities associated with forest use) and policy (i.e., legal framework and administrative and political aspects) associated with the sub-humid Mediterranean forest.

Uses of valuable broadleaves timber in Catalonia (2020)

This catalogue presents, in an accessible way, the main valuable broadleaved species, how sustainable forest management can promote the production of this wood and at the same time improve forest condition, and what the industry associated with the transformation of this resource in Catalonia is like. It includes 11 interviews with representative companies, to learn about this resource through the eyes and words of their managers. We have had the collaboration of the Catalan Wood and Furniture Guild (GFIM) and the Catalan Wood Institute (Incafust).



“Local policies, climate change and forest management in peri-urban forests: a necessary integration” handbook (2021)

This handbook aims to build bridges between local policies, the management and conservation of forest services and values, and in particular peri-urban areas, and the challenge of adapting to and mitigating the impacts of climate change. These three aspects are strongly interrelated, and it is necessary to integrate them and provide examples and concrete proposals on how to promote, from local administration, the adaptation and conservation of peri-urban forests in the context of climate change. The characteristics and values of peri-urban forests and their regulatory framework, the threats in the context of climate change and the importance of sustainable and adaptive forest management are presented. In addition, examples are given of measures and actions that can be taken via local policies to promote peri-urban forests that are more resistant and resilient to the impacts of climate change. The publication is aimed at the technical staff of local governments, local policy makers and society as a whole, especially the residents of municipalities with peri-urban forests. This handbook incorporates the conclusions of two project documents:



- Memorandum of regulatory aspects to be modified to facilitate Mediterranean sub-humid forests' adaptation to climate change
- Real case of integration of the adaptation to climate change of sub-humid Mediterranean mixed forests in local policies in the municipality of Mataró, Barcelona

Communication and dissemination



- Website in Spanish, Catalan and English www.mixforchange.eu.
- Eleven editions of [biannual newsletter](#).
- Networking: we have done exchange activities with more than 25 projects and 100 entities, including two technical trips to Tuscany and Umbria (September 2019) and Occitanie (October 2021).
- More than 10 appearances on TV and radio, more than 20 in press and more than 10 in specialized media.
- General dissemination materials of the project: information panels, brochure, advertising material.

The collage displays various communication materials from the LIFE MixForChange project. At the top left is a Spanish-language newsletter titled 'El proyecto LIFE MixForChange'. To its right is a brochure titled 'USES OF VALUABLE BROADLEAVES TIMBER IN CATALUNYA'. Below these are several information panels, including 'Buletí 1 - LIFE MixForChange' and 'Buletí 3 - LIFE MixForChange', which feature text, photos of forests, and maps of Catalonia. A central panel titled 'LIFE MixForChange: Gestió innovadora per a l'adaptació al canvi climàtic i el foment de la bioeconomia del bosc mediterrani subhúmmit mixt' provides a detailed overview of the project's objectives and results. At the bottom right, there is a small graphic titled 'Tipologies de bosc' showing different forest types.

This block shows four overlapping screenshots of the project website (www.mixforchange.eu) in different languages: Spanish, Catalan, and English. The website interface includes navigation menus, project descriptions, and contact information. The screenshots are arranged to show the multilingual nature of the project's online presence.

The challenges ahead



Challenges for silvicultural implementation

This project has served to develop, implement and demonstrate the effect of MixForChange silviculture in more than 200 ha of forest, and also to raise awareness and disseminate its usefulness and potential. In the coming years, the participating entities have the mission to continue promoting the application of the principles of this silviculture in their working areas. The main challenges for the generalisation of these principles are:

- **Training and capacitation:** these silvicultural principles need to be known and understood by all parties responsible for forest management: landowners and public and private practitioners.
- **Mindset change:** the proposed silvicultural method is an alternative or complement to conventional management (usually based on more intense and less frequent interventions) and, more importantly, to forest abandonment. Its adoption requires a mindset change and mid-long-term vision.
- **Logistics:** this silviculture generates more diverse wood products than conventional silviculture, which requires adapting the logistics of classification, transport and marketing in order to capitalise on the most valuable pieces.
- **Administrative aspects:** the various public administrations play a key role in promoting this form of silviculture, both by directly applying it in the forests they manage as well by promoting it within their sphere of authority: from making aid policies for sustainable forest management to providing direct and indirect tools to facilitate its application: strategic planning, working with local stakeholders, adapting regulations to facilitate its application, communicating with society, etc.

Post-project continuation

During the years following the end of the project, the beneficiaries will carry out the following actions:

- **Communication** addressed to different target audiences, from society in general to forest managers, in order to disseminate the opportunities presented by the silviculture developed in the project for the adaptation of Mediterranean forests to climate change.
- **Specific training** of technicians to promote capacitation on the criteria for designing and executing this form of silviculture.
- **Monitoring** of trial interventions: the forest monitoring plots established in the project are intended to be permanent plots to continue generating information over the long term.





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Generalitat de Catalunya
Departament d'Acció Climàtica,
Alimentació i Agenda Rural



Centre de la Propietat
Forestal



ASSOCIACIÓ DE PROPETARIS FORESTALS
DEL MONTNEGRE I EL CORREDOR

serra de bellmunt
associació de propietaris forestals

With the collaboration of:



**Diputació
Barcelona**