



LIFE ADAPT-ALEPPO (LIFE20 CCA/ES/001809)

"Adaptive management of Mediterranean Pinus halepensis forests in the face of climate change"

LAYMAN REPORT

LIFE ADAPT-ALEPPO





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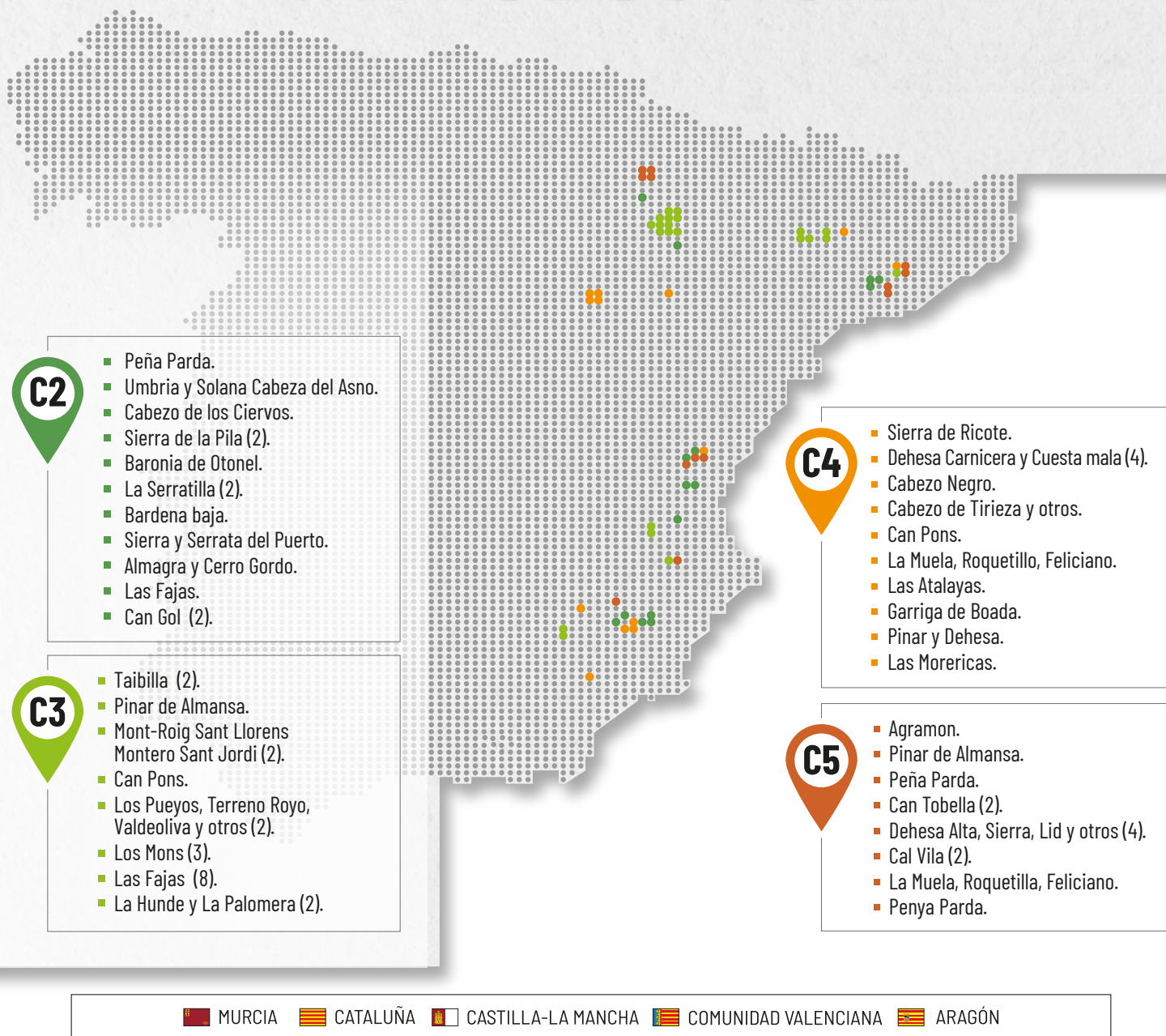
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INTRODUCTION



The LIFE ADAPT-ALEPPO Project (LIFE20 CCA/ES/001809) – “Adaptive management of Mediterranean *Pinus halepensis* forests in the face of climate change” – is a project carried out in Spain under the 2020 call of the LIFE Programme, within the Climate Action subprogramme, under the thematic area of vulnerability assessment and adaptation strategies.

The project focuses on improving the adaptive capacity of *Pinus halepensis* (Aleppo pine) forests in the face of climate change by developing and applying innovative adaptive forest management tools.

It responds to the challenges posed by prolonged droughts, wildfires and pest outbreaks, which threaten the vitality and biodiversity of these ecosystems. Its scope of implementation comprises 42 demonstration stands across 205 hectares, distributed throughout the regions of Murcia, Aragón, Catalonia, the Valencian Community and Castilla-La Mancha.



2

GOALS



The main objective of the LIFE ADAPT-ALEPPO project was the development and demonstrative application of new tools to support the adaptation of Iberian forests to climate change, specifically Aleppo pine forests (subtype 42.841 of Habitat 9540, Annex I of the Habitats Directive). These tools focus on the early detection of decline processes and on improving the resilience of this ecosystem by increasing its vigor, its capacity to adapt to increasing aridity, and its ability to recover ecosystem functions after natural disturbances.

PARTNERS

3



Natural Environment Engineering (IDEN)



Directorate-General for Natural Heritage and Climate Action, Region of Murcia



Agresta Cooperative Society



Polytechnic University of Valencia (UPV)



University of Lleida (UdL)



Higher Technical School of Agricultural and Forestry Engineering, University of Castilla-La Mancha (UCLM)



PREPARATORY ACTIONS

THESE ACTIONS FOCUSED ON THE PLANNING, DIAGNOSIS AND TECHNICAL DESIGN OF FUTURE INTERVENTIONS



A1

DIAGNOSIS AND PREVIOUS EXPERIENCES

During the first months of the project, a technical advisory committee was established, comprising 28 experts in different fields related to the adaptive management of Aleppo pine forests. In addition, a detailed assessment of 63 previous experiences in Spain on adaptive forest management techniques and tools was carried out, leading to the selection of 20 experiences that were closely monitored.



A2

SELECTION OF DEMONSTRATION STANDS

This action included the diagnosis and selection of strategic areas based on bioclimatic characteristics, fire and pest history, and water availability, as well as the identification of 42 stands where adaptive management demonstration activities were implemented.

It also includes the collaboration agreements signed with different public administrations for the authorization of the works.



CONCRETE AND MONITORING ACTIONS

Concrete actions were implemented in the field as demonstration actions, generating replicable knowledge for other Mediterranean territories. Through the monitoring actions (D), follow-up and assessment of the results were achieved, leading to valuable findings.

Development of an interactive web tool for visualization and querying

C1

HABITAT SUITABILITY MAPPING AND DECLINE TOOL

This action includes the development of habitat suitability mapping -current and future maps to identify vulnerable zones and priority areas- and the development of methodologies both for generating these maps and for detecting forest decline processes. It also includes the development of an interactive web tool for visualization and consultation:

<https://lifeadaptaleppo.agrestaweb.org>

This tool represents a technological advance that can be replicated in other ecosystems. It facilitates evidence -based decision- making, although it is crucial to integrate it into public policies and forest management at different territorial scales.



C2

ASSISTED MIGRATION IN FOREST RESTORATION

This action designed a provenance selection protocol for each planting area and a protocol for the 12 selected stands distributed across the provinces of Murcia, Valencia, Castellón, Barcelona and Zaragoza.

A total of 60 hectares have been planted, in degraded or burned areas and in aged stands lacking regeneration and containing open canopy gaps.

More than 15,000 Aleppo pine specimens from 12 provenances were planted (Iberian Aragonese (ES05), Monegros-Ebro Depression (ES06), La Mancha (ES08), Maestrazgo-Los Serranos (ES09), Levante Interior (ES10), Costa Levantina (ES11), Southeast (ES13), North Baetica (ES14), South Baetica (ES15), Cazorla (ES16), South (ES17) and Alacuás), in addition to more than 5,000 specimens of native companion species.

Monitoring of the plots revealed that both the Levante Interior provenance and Alacuás (genetic improvement material from the Alacuás clonal seed orchard) demonstrated better survival and growth. Local provenances only stood out in three of the nine plots.

Therefore, the traditional criterion of using only local sources is called into question. Climate change may be slowing local adaptive processes, which supports the proposal of using a mixture of provenances in future forest restoration actions.





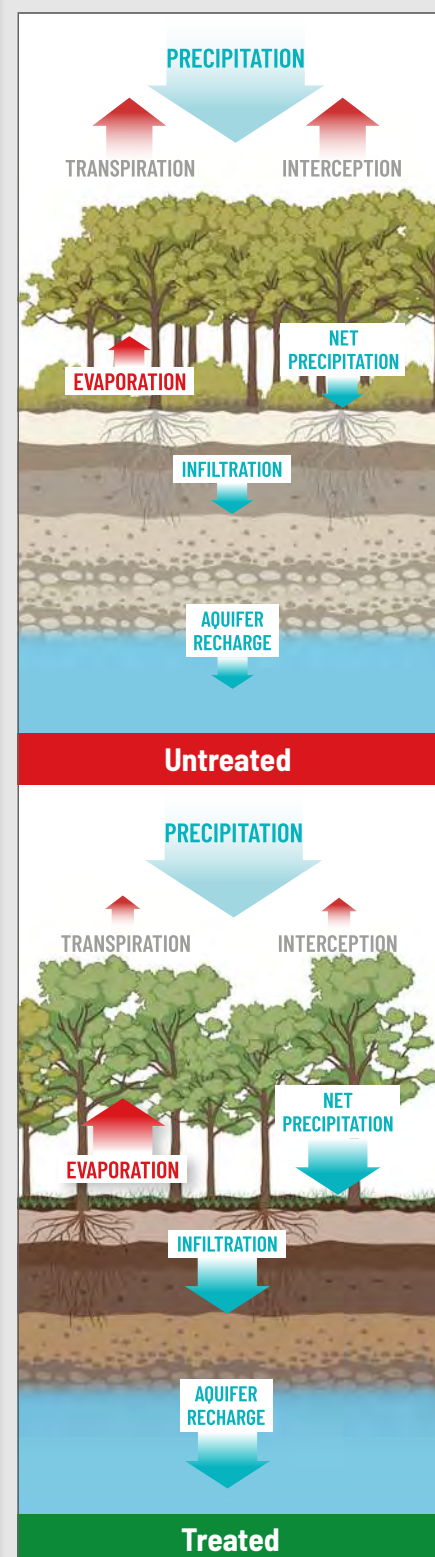
ECOHYDROLOGICAL-BASED ADAPTIVE FORESTRY



This action consisted of a controlled reduction of stand density to improve water infiltration, reduce runoff and erosion, promote aquifer recharge, and slow the spread of wildfires. It was applied in 9 stands (44 ha) using different silvicultural approaches: alleys, coppice-group systems and uniform thinning.

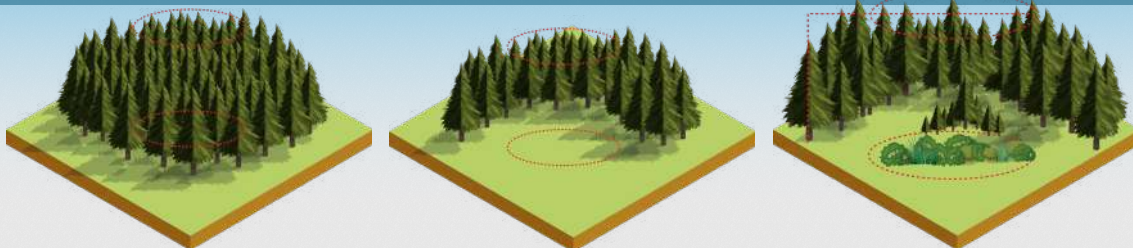
Monitoring of the plots shows that treated areas exhibit greater surplus water and aquifer recharge. For example, in Sierra de Luna, 33% more available water was recorded in the treated stand compared to the control, and in Nerpio, thinned stands increased recharge more effectively than homogeneous treatments.

Ecohydrological management enhances water-use efficiency and resilience to drought.

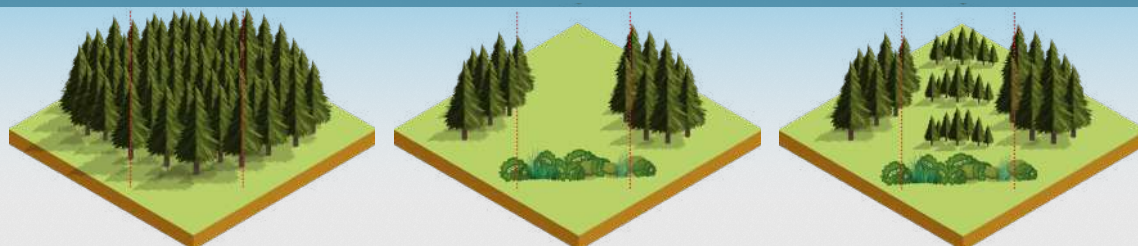


ADAPTIVE FORESTRY FOR FLORISTIC AND STRUCTURAL DIVERSIFICATION

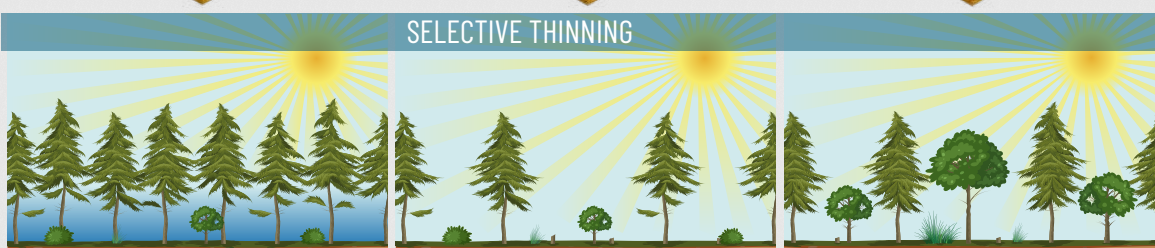
COPPICE REGENERATION



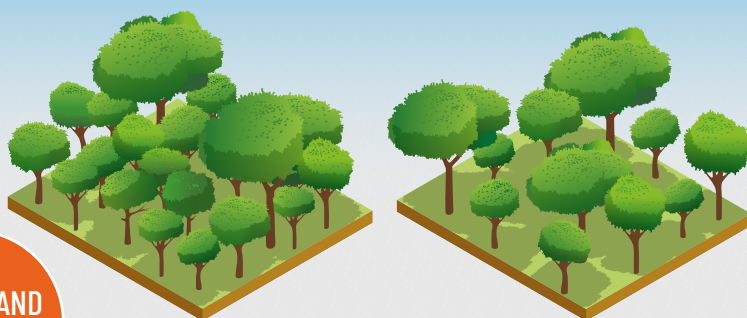
STRIP REGENERATION



SELECTIVE THINNING



REGULAR THINNING



Application of five types of treatments

- Selective thinning
- Coppice regeneration
- Strip regeneration
- Regular thinning
- Uniform successive thinning

IN 12 STANDS AND A TOTAL OF 59 HA.

An increase in the Persistence Index in all treated plots

Greater structural and light heterogeneity

Promotion of native plant species emergence

Increased resilience to disturbances, such as wildfires or pests

These practices create more balanced and resilient ecosystems in the long term. Structural and compositional diversification is essential for coping with climate-driven disruptions.





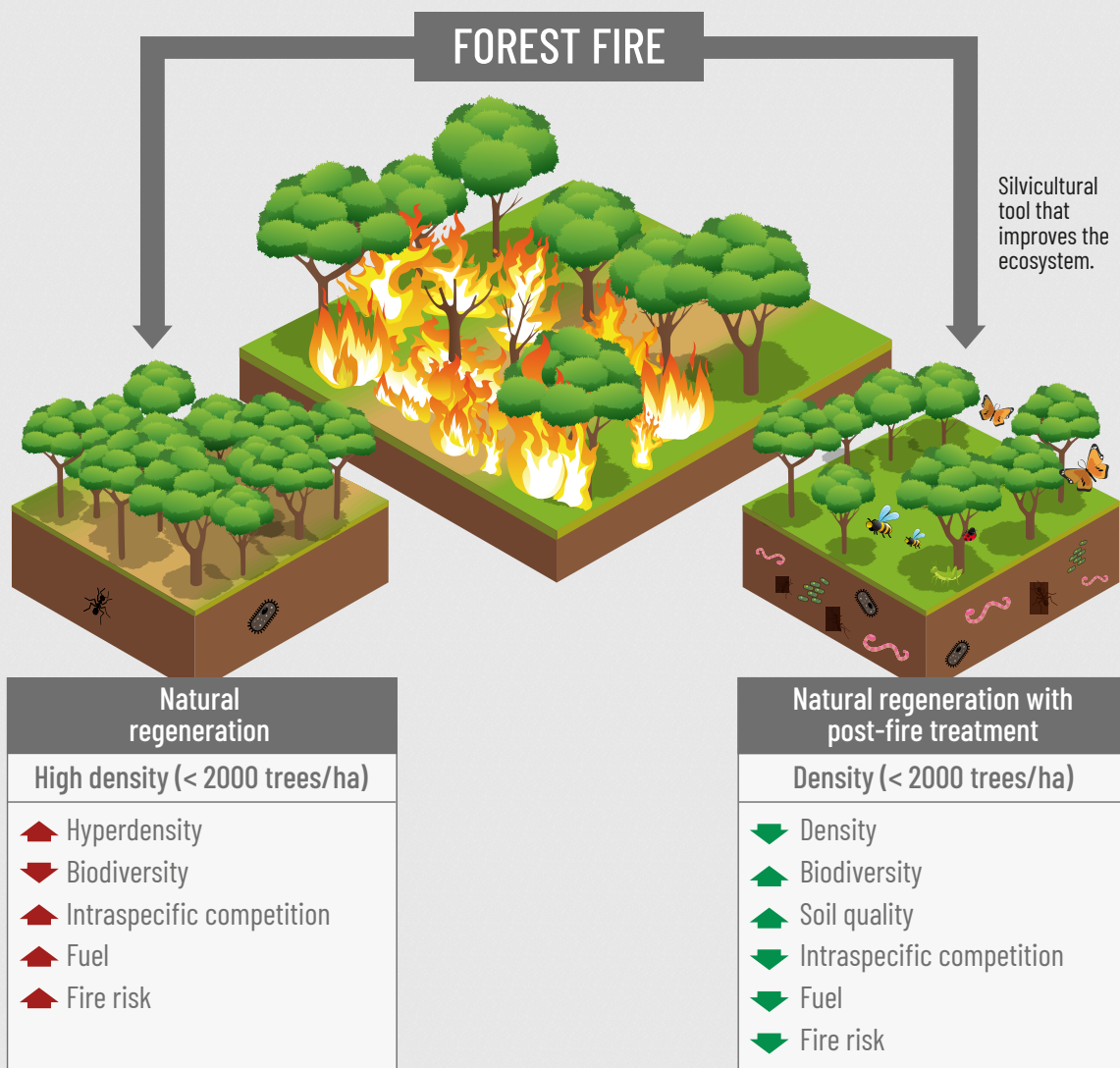
C5

POST-FIRE ADAPTIVE MANAGEMENT

In post-fire stands with massive natural regeneration (up to **70,000 trees/ha**), very intensive thinning (**>90% reduction**) was applied in **9 stands (42 ha)** to reduce intraspecific competition and future fire risk. Two target final densities were established: **900–1200 trees/ha** and **1300–1800 trees/ha**.

Following treatment, an **increase in plant diversity (Shannon Index)** and **greater shrub cover** were observed in treated areas. In addition, **higher soil enzyme activity** (β -glucosidase and phosphatase) was recorded, indicating improved soil quality.

This type of treatment **enhances post-fire resilience and adaptive capacity**, increases biodiversity and ecological stability, and contributes to the **functional restoration of ecosystems**, not just the re-establishment of vegetation cover.





C6

TRANSFER AND REPLICABILITY

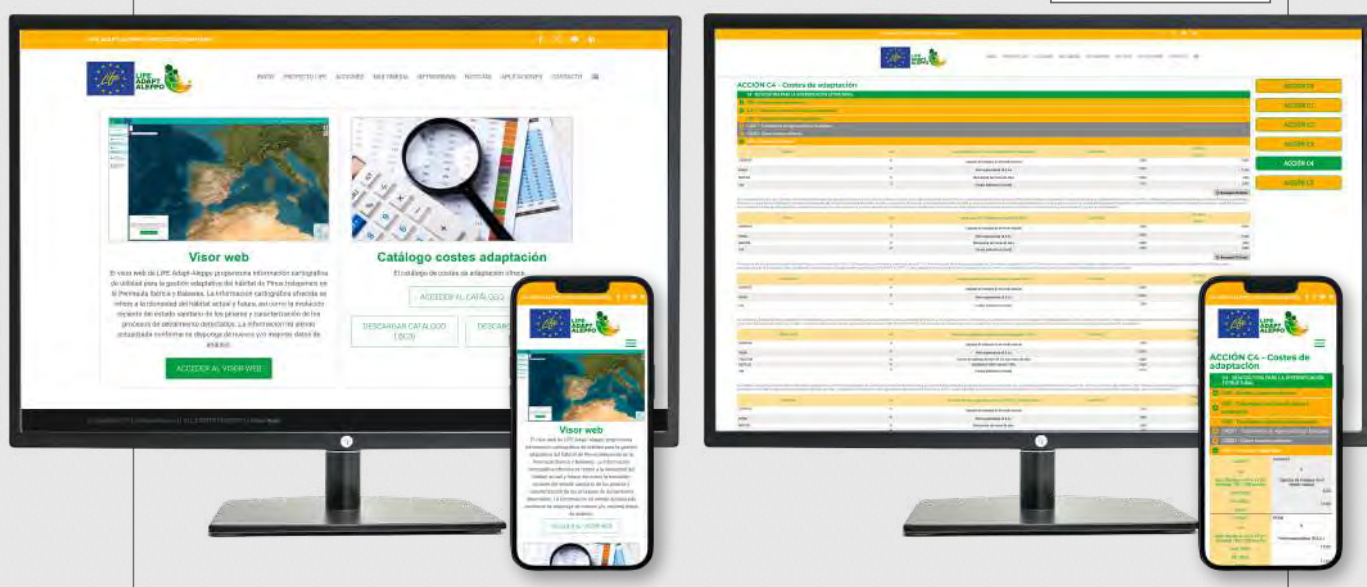
Extensive work has been carried out to transfer and replicate the actions and results of the project, including: The development of **Technical Guides for Adaptation to Climate Change in Aleppo Pine Forests in the Mediterranean**, which summarise and integrate the adaptive management models implemented in the LIFE project:

	Technical guide: “Modelling and remote sensing techniques for the adaptive management of Iberian Aleppo pine forests”	
https://adaptaleppo.eu/wp-content/uploads/2025/03/AdaptAleppo-GT_01_lr.pdf		
	Technical guide: “Implementation of assisted migration techniques in forest restoration of Aleppo pine habitat”	
https://adaptaleppo.eu/wp-content/uploads/2025/03/AdaptAleppo-GT_02_lr.pdf		
	Technical guide: “Ecohydrological forestry in Iberian Aleppo pine forests”	
https://adaptaleppo.eu/wp-content/uploads/2025/03/AdaptAleppo-GT_03_lr.pdf		
	Technical guide: “Implementation of silvicultural techniques for structural and floristic diversification in Iberian Aleppo pine forests”	
https://adaptaleppo.eu/wp-content/uploads/2025/03/AdaptAleppo-GT_04_lr.pdf		
	Technical guide: “Implementation of adaptive forestry techniques in post-fire regeneration of Aleppo pine”	
https://adaptaleppo.eu/wp-content/uploads/2025/03/AdaptAleppo-GT_05_lr.pdf		



The development of an **adaptation cost catalogue** to support decision-making and demonstrate cost-benefit ratios for the adaptive management techniques implemented in the project. This online tool is available via:

<https://adaptaleppo.eu/apps/>



The organisation of numerous **transfer and networking actions**, including training courses, coordination meetings, webinars with private landowners, transfer workshops, participation in seminars, contributions to public consultations at national and EU level, field sessions with governance groups on climate change adaptation, the signing of **10 collaboration agreements**, and the implementation of adaptive solutions in projects and plans.

The transfer and replicability actions have been successful, as the methodologies developed through LIFE ADAPT-ALEPPO are already being **replicated in multiple projects and management plans across the Mediterranean basin**.





DISCLOSURE ACTIONS



Throughout the project, numerous outreach, networking, technical dissemination and awareness-raising activities were carried out, including:

- Participation in conferences, such as the Spanish Forestry Congress (2022 and 2025) and CONAMA.
- Working sessions with numerous projects and technical groups, including: LIFE RedBosques, LIFE LiveAdapt, LIFE+REB, LIFE AgroForAdapt, LIFE WOODforFuture, SIP-ecoAdapt50, SilvAdapt, LIFE Resilient Forest, LIFE Soria Forest Adapt, COOPTREE (FORESPIR), DESFUTUR, AIDIMME, ReDec, among others.
- More than 20 technical workshops and seminars on adaptive forest management.
- A travelling exhibition (held in 9 locations) and a virtual exhibition (<https://adaptaleppo.eu/acciones/>).
- Radio interviews (Cadena SER and LleidaRadio) and media coverage in El Economista.
- Publication of informative materials available on the project website (<https://adaptaleppo.eu/multimedia-2/>), including:
 - Scientific and technical publications: technical guides and scientific/technical papers.
 - A semi-annual newsletter.
 - Informative materials: posters, flyers, and other outreach content.

ITINERANT EXHIBITION IN 9 LOCATIONS



VIRTUAL EXHIBITION - <https://adaptaleppo.eu/acciones/>





Informative material available on the project website
<https://adaptaleppo.eu/multimedia-2/>



IMPACT ACHIEVED

The LIFE ADAPT-ALEPPO project has had a significant and tangible impact beyond its pilot areas, as the methodologies developed have been replicated and transferred to numerous projects, forest management plans, climate change adaptation strategies and good practice manuals, with the support of other funding mechanisms (Next Generation EU, PRTR Funds, EAFRD, regional funds, etc.).

An example of this is the series of Good Practice Manuals prepared by the State Network of Public Forests (REMP):

		
https://remp.es/buenas-practicas/listado/prueba-de-procedencias-con-pinus-halepensis		
		
https://remp.es/buenas-practicas/listado/selvicultura-eco-hidrologica-en-pinus-halepensis-comunitat-valenciana		
		
https://remp.es/buenas-practicas/listado/gestion-adaptativa-de-la-regeneracion-posincendio-comunitat-valenciana		

Adapt-Aleppo methodologies are already being applied in:

Habitat improvement in the Sierras de Ricote and La Navela SAC and SPA	
Silvicultural improvement for diversification and resilience in areas affected by climate change, Northwest Region of Murcia (Lots 1 and 2)	
Reforestation project in "Cerro Vicente", Chinchilla de Monte-Aragón (Albacete)	
DECAPIN-IA CYL, Artificial Intelligence System for detecting decline in Pinus pinaster in Castilla y León	

LIFE ADAPT-ALEPPO has not only achieved its objectives, but has multiplied its impact thanks to the replication of its methodologies, generating far-reaching environmental, social, economic and policy benefits.

• TECHNICAL REPLICABILITY

Assisted migration, ecohydrological silviculture, diversification silviculture and post-fire silviculture have been adopted as reference models.

These methodologies have been incorporated into regional forest planning instruments and projects funded by EU programmes, demonstrating their scientific and operational validity.



• ENVIRONMENTAL BENEFITS

The applied techniques have resulted in greater survival and resilience in *Pinus halepensis* forests.

Carbon sequestration has increased, contributing to climate change mitigation.

Ecohydrological treatments have improved water efficiency, with gains of up to 33% more available water in treated plots.

In post-fire areas, increases in plant diversity and soil quality have been recorded, improving overall ecosystem functioning.



• SOCIOECONOMIC IMPACT

The replication of these practices has led to the creation of specialised employment in adaptive forest management, both in public and private sectors.

New opportunities have emerged for forestry companies, consulting firms and nurseries due to the growing demand for adapted genetic material and new management techniques.



• DEMONSTRATIVE IMPACT ON POLICIES

The project has served as a reference for national and regional regulations and strategies, in line with the National Climate Change Adaptation Plan (PNACC) and regional Forest Strategies.

It has strengthened the role of Mediterranean forests as carbon sinks and as key elements for resilience against drought and wildfire risks.





CONCLUSIONS

The LIFE ADAPT-ALEPPO project has demonstrated the importance of adaptive forest management in the context of climate change. The actions implemented have generated scientific evidence and practical results that facilitate decision-making in the management of Mediterranean pine forests, ensuring their long-term sustainability.

The monitoring results of the demonstration activities carried out through the LIFE ADAPT-ALEPPO project confirm that certain adaptive actions consistently improve the response of Aleppo pine stands to climate change. Furthermore, these actions are replicable in other forest species and territories.

These practices not only increase forest resilience, but also provide additional benefits such as biodiversity conservation, improved ecosystem services and enhanced soil and water protection. The comprehensive approach of LIFE ADAPT-ALEPPO can serve as a model for other adaptive forest management initiatives in the face of climate change.

Ultimately, the results confirm the importance of combining advanced technologies, such as cartographic monitoring tools, with innovative silvicultural approaches, including assisted migration and ecohydrological and diversification-based forestry. These actions show great potential for mitigating the impacts of climate change on Mediterranean forest ecosystems.





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