Layman's REPORT

LIFE18ENV/IT/000124

Close-to-nature foreSt SusTainablE Management under Climate Changes

CONTENT OF THE PROJECT

In 2018 the LIFE Programme, the EU's funding instrument for the environment and climate action, offered the opportunity to present projects that further develop and deepen the topic of forest monitoring by providing all the relevant data they can generate for current or future European forest information systems. In addition, it called for effective and efficient application of tools, methodologies, techniques, technologies and equipment to implement close-to-nature forest management approaches and similar silvicultural alternatives to more intensive forest management and/or management approaches based on planted even-aged and single-species stands. The impact of climate change on forest systems is recognised worldwide and its effects are increasingly visible in European forests. Nowhere is this more evident than in the Mediterranean region, where rising temperatures and the increasing frequency of extreme events such as storms, heatwaves and prolonged droughts pose a significant threat to forest ecosystems. These negative effects of new challenges for Sustainable Forest Management (SFM) required innovative approaches to protect and preserve forests as vital natural resources.
The genetic diversity of forest tree populations has a crucial role in ability of forests to cope with climate change and other threats. Genetic diversity serves as the foundation for the long-term evolutionary processes that enable forests to maintain their adaptive potential in the face of environmental changes.
In this context, the LIFE SySTEMiC project (Close-to-nature foreSt SusTainablE Management under Climate Changes) is providing important information and strategies for more effective conservation of genetic diversity of tree populations in forests.

PROJECT OBJECTIVES

The general aim of the LIFE SySTEMiC project is to use the "tool" of genetic diversity to help our forests in times of climate change. The basic idea is relatively simple: the higher the genetic diversity of the trees in forests, the more likely it is that some trees will have genetic characteristics that make them more adaptable to rapidly changing climate, thereby increasing the resilience of the forest ecosystem.
Based on these premises, the main project objectives have been to:

1. Investigate the relationships between forest management and genetic diversity for eight forest tree species in three European countries (Croatia, Italy, Slovenia) to identify the silvicultural systems that maintain high levels of genetic diversity.
2. Develop an innovative Genetic Biodiversity and Silvicultural model (GenBioSilvi) based on the combination of advanced landscape genomics, applied genetics, and silvicultural models to support SFM.
3. Disseminate of the knowledge about the method across Europe and to transfer its use into forestry practice by involving different types of stakeholders.

Forest owners, forest managers, national, regional, and local forest offices, academic and research institutions, forest certification schemes, and all institutions and organisations involved in forest management, protection and biodiversity conservation are the main beneficiaries of the GenBioSilvi tool.

PROJECT AREAS

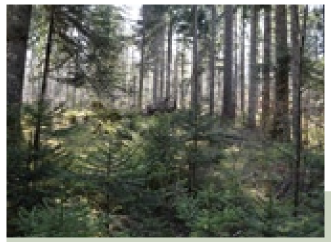
Analyses were carried out on 31 selected forest areas including existing Dynamic Genetic Conservation Units (DCU) from the EUFGIS (European information system on forest genetic resources (www.eufgis.org), forest reserves and different categories of managed forests in Italy, Croatia and Slovenia. Area selection was done for eight forest tree species: silver fir (*Abies alba* Mill.), beech (*Fagus sylvatica* L.), black pine (*Pinus nigra* J.F. Arnold.), stone pine (*Pinus pinea* L.), maritime pine (*Pinus pinaster* Aiton), pedunculate oak (*Quercus robur* L.), pubescent oak (*Quercus pubescens* Willd.) and holm oak (*Quercus ilex* L.). The selection of sites considered different European Forest Types, managed with different intensities or unmanaged (forest reserves) to estimate the influence of forest management on forest structure and its above and below ground biodiversity, and to enable the preparation of the GenBioSilvi model.

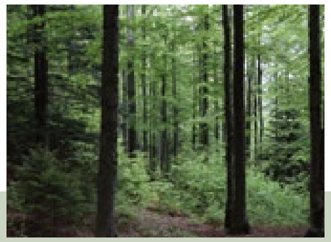
Table 1 shows an overview of the selected forest sites.

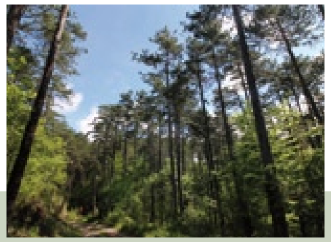
Table 1. The overview of Life SySTEMiC sites, presented by name of the site, country, analysed tree species, European forest type, stand structure and silvicultural system.

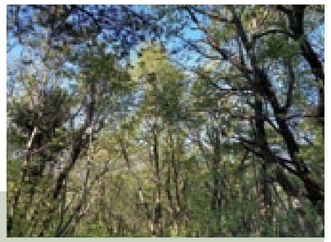
Id	Site name	Country	Species	EFT*	Structure	Silvicultural system
01	Pian degli Ontani	Italy	*F. sylvatica*	7.3	Even-aged	Uniform shelterwood
02	Baldo's forest	Italy	*F. sylvatica*	7.3	Uneven-aged	Individual tree selection system
03	Pian dei Ciliegi	Italy	*F. sylvatica*	7.3	Even-aged	Uniform shelterwood
04	Caselle 1	Italy	*F. sylvatica*	7.3	Even-aged	Uniform shelterwood
05	Caselle 2	Italy	*F. sylvatica*	7.3	Even-aged	Uniform shelterwood
06	Faltelli	Italy	*A. alba*	10.6	Even-aged	Uniform shelterwood
07	Tre Termini	Italy	*A. alba*	7.3	Unven-aged	Individual tree selection system
08	Terminaccio	Italy	*P. pinea*	10.1	Even-aged	Clear-cutting and planting
09	Fossacci	Italy	*P. pinea*	10.1	Even-aged	Clear-cutting and planting
10	Culatta	Italy	*Q. robur*	5.1	Uneven-aged/Unmanaged	Unmanaged
11	Fonte Novello	Italy	*F. sylvatica*	7.3	Uneven-aged/Old-growth	Unmanaged
12	Venacquaro	Italy	*F. sylvatica*	7.3	Even-aged	Uniform shelterwood
13	Nova Gradiška	Croatia	*Q. robur*	5.1	Even-aged	Uniform shelterwood
14	Ogulin	Croatia	*F. sylvatica*	7.2	Even-aged	Uniform shelterwood
15	Zadar	Croatia	*P. pinea*	10.1	Even-aged	Clear-cutting and planting
16	Gorski kotar, Skrad	Croatia	*A. alba*	3.2	Uneven-aged	Individual tree selection system
17	Klana	Croatia	*P. nigra*	3.3	Even-aged	Uniform shelterwood
18	Brač	Croatia	*P. nigra*	10.2	Even-aged	Irregular shelterwood
19	Pelješac	Croatia	*P. pinaster*	10.1	Even-aged	Irregular shelterwood
20	Pula	Croatia	*Q. ilex*	9.1	Even-aged	Uniform shelterwood
21	Črni kal	Slovenia	*Q. pubescens*	8.1	Even-aged	Irregular shelterwood
22	Mlake	Slovenia	*P. nigra*	14.1	Even-aged	Uniform shelterwood
23	Osankarica	Slovenia	*F. sylvatica*	7.2	Even-aged	Irregular shelterwood
24	Pri Studencu	Slovenia	*F. sylvatica*	6.6	Even-aged	Irregular shelterwood
25	Rajhenavski Rog	Slovenia	*F. sylvatica*	7.4	Uneven-aged/Old-growth	Unmanaged
26	Smolarjevo	Slovenia	*A. alba*	3.2	Uneven-aged	Individual tree selection system
27	Leskova dolina	Slovenia	*A. alba*	7.4	Even-aged	Irregular shelterwood
28A	Krakovo (Managed)	Slovenia	*Q. robur*	5.1	Even-aged	Uniform shelterwood
28B	Krakovo (Reserve)	Slovenia	*Q. robur*	5.1	Uneven-aged/Unmanaged	Unmanaged
29	Gorski kotar, Vrbovsko	Croatia	*F. sylvatica*	7.2	Uneven-aged	Individual tree selection system
30	La Verna	Italy	*A. alba*	10.6	Uneven-aged/Old-growth	Unmanaged
31	Mljet	Croatia	*P. pinea*	10.1	Even-aged	Uniform shelterwood

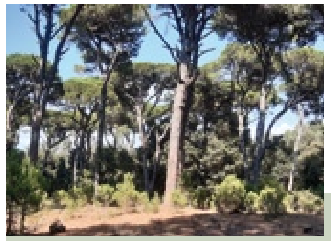
*EFT = European Forest Type: 3.2 Subalpine and mountainous spruce and mountainous mixed spruce-silver fir forest; 3.3 Alpine Scots pine and Black pine forest; 5.1 Pedunculate oak-hornbeam forest; 6.6 Illyrian submountainous beech forest; 7.2 Central European mountainous beech forest; 7.3 Apennine-Corsican mountainous beech forest; 7.4 Illyrian mountainous beech forest; 8.1 Downy oak forest; 9.1 Mediterranean evergreen oak forest; 10.1 Mediterranean pine forest; 10.2 Mediterranean and Anatolian Black pine forest; 10.6 Mediterranean and Anatolian fir forest; 14.1 Plantations of site-native species.

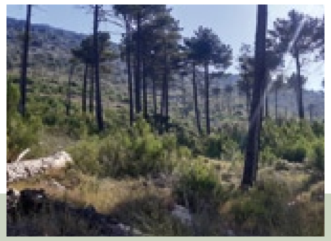

Abies alba, Photo R. Damjanić


Fagus sylvatica,- Photo K. Sever

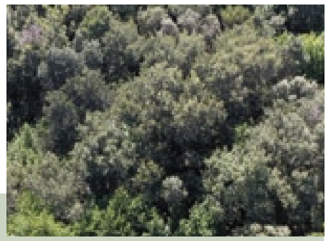

Pinus nigra, Photo M. Lanšćak


Quercus pubescens, Photo K. Sever


Pinus pinea, Photo D.Travaglini


Pinus pinaster, Photo D.Travaglini


Quercus robur, Photo D.Travaglini


Quercus ilex, Photo M. Lanšćak

More detailed information about project sites is available at the Life SySTEMiC web page: https://www.lifesystemic.eu/demonstration-sites/

ACTIVITIES AND ACHIEVEMENTS OF THE PROJECTS

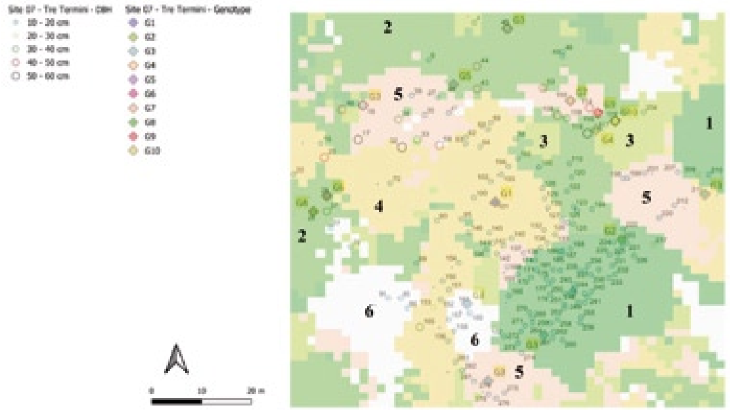
The most important activities and results are summarised in this chapter. They are categorised by species. However, the detailed results are reported in the project outputs, such as Handbook for sustainable forest management, Guidelines on sustainable forest management for all in project analysed tree species and other deliverables, that are available on the project website (https://www.lifesystemic.eu/).
Forest structure and landscape genomics have been analysed, for every of the eight selected species. Soil biodiversity and the influence of browsing* were studied in beech and Silver fir stands, respectively. We also tested the GenBioSilvi model for all eight species and performed felling on selected stands to test the influence of forest management measures on genetic diversity of forest stands. As a result of the project, recommendations for forest management** for each of the eight species have been prepared. We present short findings for each forest tree species below.
*Browsing: The impact of ungulate browsing on different species and growth stages of forest trees varies significantly. Young forests, particularly during early growth stages, often face heightened browsing pressure, severely affecting the survival and growth rates of tree saplings. Species such as oak and beech, more resistant to browsing, might withstand this pressure better than fir and pine, which are more susceptible.
**Recommendations for forest management: Knowledge of genetic variability from an adaptive perspective can improve forest management decisions and anticipate assisted migration efforts. This is crucial for preserving Forest Genetic Resources (FGR) and enriching stands with favourable genotypes, ensuring forest resilience and genetic diversity.


Site 30 - La Verna, old-growth forest

Silver fir - *Abies alba* Mill.

Forest structure, deadwood and tree-related microhabitats
Silver fir was the prevailing tree species on sites in Skrad (Croatia) and Leskova dolina (Slovenia); in the remaining sites silver fir was most often mixed with beech, Sycamore, Norway spruce and other secondary tree species. Forest structure diversity was high in the old-growth stand followed by uneven-aged and even-aged stands. The total volume of deadwood ranged between 14 m^3/ha and 426 m^3/ha. The old-growth stand had the largest amount of deadwood (426 m^3/ha).

Landscape Genomics
To identify a signature of local adaptation, we conducted Genotype Environment Association (GEA) analyses. The results of the analysis showed the basal adaptation genotype of silver fir could spread in the Central European range. Analysing the pattern of genetic diversity distribution, we observed that silver fir stands managed according to individual tree selection have a complex and heterogeneous spatial genetic structure. An interesting finding is the number of allelic variants associated with bioclimatic indicators that characterise the local environment found at the Site 07 - Tre Termini.


LFMM analysis Site 07 - Tre Termini




Sapling height measurement (left), browsing damage assessment (middle) and of the inventory (right).

Browsing
Despite the noticeable effects of ungulate browsing on natural regeneration structure and composition, no significant genetic effects were detected. Genetic diversity did not differ significantly between adult silver fir trees and their regeneration, whether in fenced or unfenced plots.

GenBioSilvi model
To investigate biodiversity in forest ecosystems, we analysed indicators including genetic diversity, forest structure, deadwood, and tree-related microhabitats conditions.
In Silver fir stands, we observed that in unmanaged or old-growth forests biodiversity in preserved and sometimes even increased. In individual tree selection forests biodiversity is conserved by mimicking old-growth conditions and promotion of natural regeneration, thus enhancing genetic diversity and improve climate change adaptation.

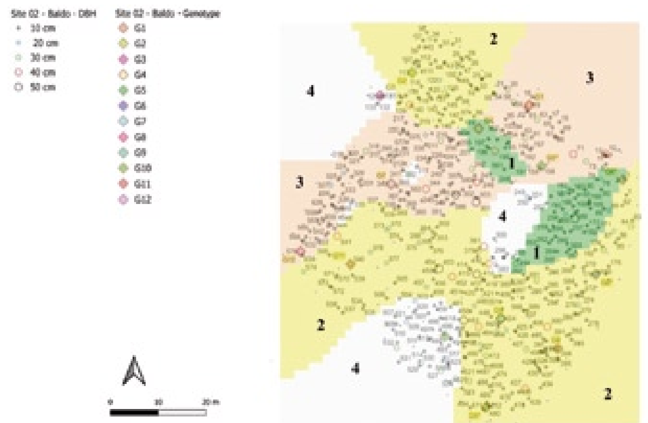
Recommendations for Sustainable Forest Management
Knowledge about influence of forest management on genetic variability of tree species can improve forest management decisions and anticipate assisted migration efforts. For Silver fir stands, the individual tree selection forest management practices are recommended, which are associated with populations having a high probability of adaptation.

Beech - *Fagus sylvatica* L.

Forest structure, deadwood and tree-related microhabitats
Beech was the prevailing tree species in most studied sites (01, 02, 03, 05, 11, 12, 14, 23, 24); in the remaining sites beech was most often mixed with Silver fir, Sycamore, Large-leaved and other secondary tree species. Forest structure diversity was high in the old-growth stands, followed by uneven- and even-aged stands. The total volume of deadwood ranged between 5 m^3/ha and 420 m^3/ha. The old-growth stands (Sites 11, 25) had the largest amount of deadwood (329 m^3/ha an average value). The frequency of the tree-related microhabitats differed a lot between studied sites.


Deadwood and tree-related microhabitats in the Site 11 - Fonte Novello, old-growth forest.

Landscape Genomics
To identify a signature of local adaptation, we conducted Genotype Environment Association (GEA) analyses. In general, we found a high number of specific allelic variants in unmanaged sites and old-growth forests. The creation of gaps in forest cover and the complexity of structure characterizing these stands could be linked to a higher probability of gene recombination between genotypes belonging to different family clusters. These patterns are like those found in old-growth forests and unmanaged populations. Less impactful management types, such as individual tree selection, appear to report a population with a high number of allelic variants associated with bioclimatic indicators. Similar results have been observed in unmanaged stands and old-growth forests.


LFMM analysis results and genotype distribution map of Site 02 - Baldo's forest.

Soil biodiversity

The short-term effects of individual tree removal included decreased species richness and a lower diversity of ectomycorrhizal fungi on the remaining trees' roots. However, the overall fungal community's richness and diversity were unaffected.

Ectomycorrhizal fungi on beech roots

GenBioSilvi model

To investigate biodiversity in forest ecosystems, we analysed indicators including genetic diversity, forest structure, deadwood, soil diversity, and tree-related microhabitats.

We observed that unmanaged and old-growth forests conserved and increased biodiversity. Managed sites with individual tree selection forest management practices showed similar biodiversity levels. Genetic diversity analysis revealed that old-growth forests, individual tree selection sites had complex spatial genetic structures, unlike uniform and irregular shelterwood-managed stands.

Recommendations for Sustainable Forest Management

Project results show that knowledge about influence of forest management practices on genetic variability of beech can improve forest management decisions and anticipate climate change adaptation efforts such as assisted migration of beech populations within its range. Assisted migration involves humans moving tree species to new areas where the climate and environmental conditions are more suitable for their growth and survival, usually due to climate change affecting their native habitats. This is crucial for preserving beech forest genetic resources and enriching stands with favourable genotypes, ensuring forest resilience and genetic diversity.

In beech forest stands less impactful management practices are recommended, such as individual tree selection system, which are associated with populations having a high number of allelic variants in response to bioclimatic indicators. Similar results have been observed in unmanaged stands and old-growth forests.

Deadwood in the Site 9A - Fossacci

Pinus spp (Black pine - *Pinus nigra* J.F. Arnold., Stone pine - *Pinus pinea* L., Maritime pine - *Pinus pinaster* Aiton)

Forest structure, deadwood and tree-related microhabitats

Analysed Stone pine and Black pine stands were managed as even-aged stands. Maritime pine site was managed as irregular shelterwood system.

In the Stone pine stands, the total volume of deadwood ranged between 6 m^3/ha and 20 m^3/ha.

Black pine stands had an average volume of deadwood of 21 m^3/ha. In the Maritime pine site the amount of deadwood was 42 m^3/ha.

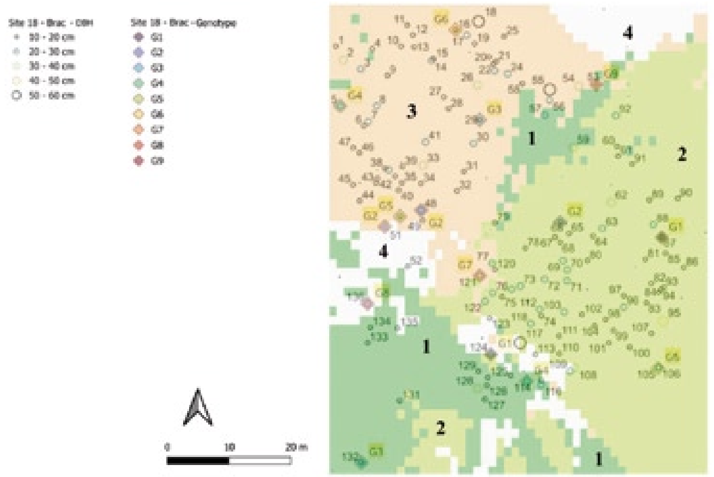
The deadwood was the most common form of tree-related microhabitats in Stone pine. Deadwood, epiphytes injuries and wounds were common in the Black pine stands. Cavities, injuries wounds and other forms of microhabitats were almost equally represented in the Maritime pine sites.

Landscape Genomics

To identify a signature of local adaptation, we conducted Genotype Environment Association (GEA) analyses. The global analysis allowed us to identify possible patterns of adaptation to the bioclimatic conditions that characterize the range of pine populations. The results of the analysis showed the existence of three different clusters for Stone pine, and four clusters for Black pine.

GenBioSilvi model

To investigate biodiversity in forest ecosystems, we analysed indicators including genetic diversity, forest structure, deadwood, and tree-related microhabitats. Based on microsatellite (nSSR) data, all sites exhibited simplified spatial genetic structures. However, we observed high genetic diversity associated with genes involved in responding to abiotic stress.



LFMM analysis results and genotype distribution map of Site 18 - Brač

Recommendations for Sustainable Forest Management

For pine species, which have been studied within the project, and which typically show low level of biodiversity (except for Black pine) forest management practices that increase forest stand complexity with a multi-layered vertical structure are recommended. Diversification of silvicultural approaches and promotion of age-stand structure facilitates pollen dispersal, promote genetic diversity, and increase new allelic variants, important for climate change adaptation.

Quercus spp (Pedunculate oak - *Quercus robur* L., Downy oak - *Quercus pubescens* Willd., Holm oak - *Quercus ilex* L.)

Forest structure, deadwood and tree-related microhabitats

Three oak species have been studied within LIFE SySTEMiC project. Pedunculate oak was the prevailing tree species in Site 28A - Krakovo (Managed), mixed with Common hornbeam. In the other sites Pedunculate oak was most often mixed with Narrow-leaved ash, Common hornbeam and other secondary tree species. Downy oak was the prevailing tree species in Site 21 - Črni kal, mixed with South European flowering ash and other secondary tree species. Holm oak was the most frequent species in Site 20 - Pula, mixed with Downy oak and Bay laurel.

Tree-related microhabitats in the Site 10 - Culatta.

The total volume of deadwood in the Pedunculate oak stands ranged between 13 m^3/ha and 490 m^3/ha. The unmanaged stands (sites 10 - Culatta, 28B - Krakovo (Reserve)) had the largest amount of deadwood, represented by downed dead trees, snags and other lying deadwood pieces. The total amount of deadwood in the Downy oak stand and in the Holm oak stand was 7 m3/ha and 16 m3/ha, respectively.

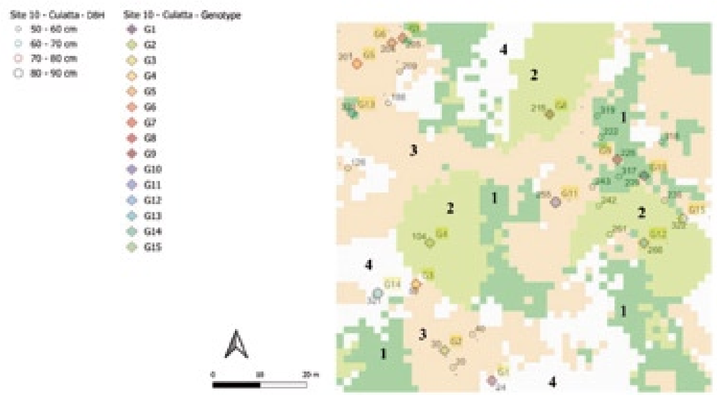
Almost all forms of microhabitats (cavities, injuries and wounds; bark; deadwood; deformation/growth form, epiphytes, nests) were detected in *Quercus* sites.

Landscape Genomics

To identify local adaptation signatures in oak stands, we conducted Genotype Environment Association (GEA) analyses. The results of the analysis showed the existence of four different genotypes present in Italy, Croatia and Slovenia. Management applied to oak stands appears to result in a simplified spatial genetic structure compared to that observed in unmanaged sites and old-growth forests.

Oak mildew

As part of the LIFE SySTEMiC project different ways of controlling oak mildew at one of our experimental sites in Krakovo Forest (Slovenia) were tested.



LFMM analysis results and genotype distribution map of Site 10 - Culatta

GenBioSilvi model

Based on the results obtained, we can assume that there is high genetic diversity in all sites but we cannot conclude that there is significant genetic diversity between the sites even though they differ in management types.

Recommendations for Sustainable Forest Management

Silvicultural system that is most suitable for pedunculate oak forests is irregular shelterwood with larger openings or uniform shelterwood system, which covers oak demand for light.

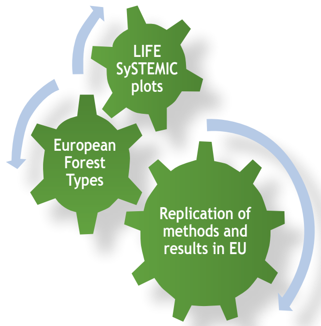
For oak species that showed similar characteristics to those included in our study, we suggest using a type of management that increases forest stand complexity with a multi-layered vertical structure that positively affects on conservation of genetic diversity and increases new allelic variants crucial for climate change adaptation.

The forest restoration system in oak stands needs to be adapted to the increasingly frequent natural disasters, mostly through diversification of the size of the areas for restoration, as this ensures the mosaic structure of future stands and increases their resilience.

GUIDELINES ON MANAGEMENT ACTIVITIES IN FOREST CONSERVATION AREAS IN CLIMATE CHANGE FOR EACH OF THE 4 SPECIES/GENERA COMPLEXES TARGETED

Our implementation actions lead to better adapted close-to-nature forest management guidelines, support forestry practices, and policy recommendations. Life SySTEMiC considered not only past management practices based on National Forest Inventory data, but also the predictive model, GenBioSilvi, developed within the project to assists with future scenarios and adaptability of forest trees and forest ecosystems. Silvicultural techniques implemented today in Europe do not consider indicators or guidelines that aim to enhance genetic diversity.
Therefore, the data collected concerning genetic, forest, and biodiversity were implemented into the developed GenBioSilvi model for sustainable forest management (SFM) and used to provide guidelines which are applicable in the EU for the species considered in the project. LIFE SySTEMiC has contributed to the harmonisation of information from data collected in EU forests present in different European Forest Types across 3 EU countries and subjected to different management, providing specific guidelines for sustainable forest management to help maintain forest ecosystem biodiversity, forest genetic resources and forest productivity over time, maintaining the adaptive potential of forests.
The suggestions reported in the guidelines are useful to maintain forest ecosystem biodiversity in agreement with target priorities of the EU Biodiversity strategy 2030 [COM(2020) 380)], and the Competent Authorities of the Member States.

REPLICABILITY AND TRASFERABILITY



The multidisciplinary approach in several protected and managed forests in different European Forest Types produced standardised protocols to favour the replicability of the results, organised stakeholder meetings at EU level, and identified the potential transfer sites outside the project countries (Italy, Croatia and Slovenia) during the first stakeholders meeting, securing their interest in the project methods and tools.
LIFE SySTEMiC provided a replicability and transferability exploitation plan, to tangibly use the project results also outside the project regions, to multiply and use them in other contexts.
This plan consists of 1) identification of replication and transfer sites; 2) protocol for optimization and replicability of results and 3) budgetary requirements per level.
LIFE SySTEMiC stakeholder, Parco Nazionale della Sila (Italy) has replicated the method in a newly established site of Black pine during the project.
LIFE SySTEMiC also signed letters of intent to collaborate in a joint project with the coordinator of the ongoing Horizon Europe project “Sustainable Management models and valUe chains foR small Forests” (SMURF), and with the coordinators of the proposal “Managing Ecosystems to Drive Forests towards Optimum Resilience for Ensuring a Sustainable Tomorrow” (MEDFOREST) submitted under the Interreg NEXT MED programme call, and the proposal “Restore and improve the conservation status of threatened forests by holm oak dieback” (LIFE RECLOAK) submitted to the call 2024 LIFE-2024-SAP-NAT (Topic LIFE-2024-SAP-NAT-NATURE).

DISSEMINATION AND COMMUNICATION ACTIVITIES

Several activities were carried out to communicate and disseminate the project results. Part of these activities concerned the creation of the website and other social media, the organisation of seminars and participation in other initiatives (networking). The target audience was public institutions and private organisations/owners active in environmental monitoring, forest management and policy, as well as the general public interested in environmental protection.
Key events and dissemination activities included: press conferences, TV and radio appearances, videos of sites, social media posts (Facebook, Twitter, Instagram, YouTube), workshops, educational visits, networking with other projects, conferences.
The results of the LIFE SySTEMiC project were presented at the final conference to organisations specialising in monitoring and nature conservation, as well as public and private institutions involved in nature conservation and forest protection and sustainable forest management. (i.e. forest certification schemes).

SOCIO-ECONOMIC CONTEXT OF THE PROJECT

Social impact

The project mainly involved professionals from the foresty sector at different levels (from students to researchers, forest owners and managers, to forest policy makers). An important outcome of the project is scientific publications and participation in conferences (overall 15 papers in national or international journals or abstracts in international conferences and about 4 scientific papers have been submitted by the end of the project).

Nevertheless, considerable efforts were made to involve a wider audience: presence on traditional media (television and radio) and new media (websites); presence on social media platforms (Facebook, twitter, Instagram) and public events (visits to sites, open days, educational day for students and teachers, field trip for students) were organised by LIFE SySTEMiC.

Questionnaires were submitted (> 700 responses in total) to get people more involved and to determine their knowledge and awareness of sustainable forest management, the protection of biodiversity and the genetic resources of forests. Overall, there was a high level of awareness of global change and Natura 2000, and particular attention to the protection of biodiversity (e.g. releasing old trees, avoiding logging during the breeding season of birds) and the impact of climate change on forests is considered necessary to improve sustainable forest management.

Economic impact

By changing ecological conditions affecting forest species, climate change will greatly affect SFM. Species distribution models developed by the LIFE SySTEMiC project evaluate, for example, that in Italy, Croatia, and Slovenia, the high suitability areas for Beech will be greatly reduced (by approximately 86% under medium-risk scenarios, RCP 4.5). In a single forest, such as the “Pratomagno forest” (Arezzo, Italy) which also includes project Site 03 - Pian dei Ciliegi, the area occupied by Beech, that is currently about 1,100 hectares (mainly high or medium suitability), will reduce to 750 hectares (mainly low or medium suitability) even under low-risk (RCP 2.5) scenarios.

In these scenarios, the conservation of Forest Genetic Resources and the increase of Genetic Diversity are of vital importance. We tried to assess the short- and medium-term economic impact of Sustainable Forest Management (SFM) in beech forests (as proposed by the project’s guidelines) by comparing the intervention carried out in the Pian dei Ciliegi site, which aims to shift forest structure from even-aged to uneven-aged, with the “traditional thinning” usually carried out in even-aged stands in the same area. Volume of harvested wood is quite similar (44.4 m^3/ha in LIFE SySTEMiC interventions, about 42 m^3/ha in traditional thinning) as well as the value of the harvested wood (almost all firewood, respectively about 2300 €/ha and 2100 €/ha) while total cost is lower in LIFE SySTEMiC (about 7300 €/ha) than in traditional thinning (about 9200 €/ha). Regarding the long-term economic impact, we evaluated, as an example, Site 02 - Baldo’s forest. This forest has been managed by the owner as a family business for many decades as an uneven-aged beech forest. Approximately 30-50 trees are cut down per year (over a total area of 10 ha), generating roughly 1200 €/ha per year. In the LIFE SySTEMiC intervention at Site 02 - Baldo’s forest, the volume of harvested wood is quite high (63.3 m^3/ha). This type of intervention also provides high-quality timber: the logs are usually sold to the furniture industry for veneer, while branches and smaller materials are sold as firewood.

In the same way, we compared traditional forest management in Stone pine forests (clear-cut and planting) with the LIFE SySTEMiC interventions (uniform shelterwood system and group selection system, both aimed at achieving natural regeneration) in the Parco Regionale San Rossore Migliarino Massaciuccoli (Pisa, Italy) (sites 08, 9A, 9B). The volume of harvested wood is greater in the clear-cut system (about 65 t/ha) and the uniform shelterwood system (20 t/ha) compared to the group selection system (11 t/ha). Consequently, the total revenue is higher for the clear-cut (5300 €/ha) and uniform shelterwood system (1700 €/ha) compared to the group selection systems (900 €/ha). The cost of cutting is 2900 €/ha for the clear-cut, 1900 €/ha for the uniform shelterwood system, and 1400 €/ha for the group selection system. However, the uniform shelterwood and group selection systems avoid the additional costs of reforestation (about 3600 €/ha), fencing (8400 €/ha), or shelter (4800 €/ha), which are necessary to regenerate a Stone pine forest after clear-cutting.

However, it is worth noting that the influence of forest management practices on the total economic value of the forests should consider not only wood supply but also other important ecosystem services that were not considered in our study.

PROJECT FOLLOW-UP AND POLICY CONTEXT OF THE PROJECT

After the conclusion of the project some activities will be continued to disseminate the outputs of the project and to implement the knowledge of the study areas.

- Monitoring and evaluation the effect of the cutting performed during the projects in sites: 02 - Baldo’s forest, 03 - Pian dei Ciliegi, 06 - Faltelli, 07 - Tre Termini, 08 - Terminaccio and 09 - Fossacci.
- Evaluation of browsing in fenced and non-fenced areas established during the projects in sites 03 - Pian dei Ciliegi, 05 – Caselle 2, 06 - Faltelli, 07 - Tre Termini, 08 – Terminaccio, 09 – Fossacci, and 10 - Culatta.
- Institutional communication tools will be also used to report relevant activities carried on within the project (Institutional website, internal press, fairs, etc.).
- Dissemination of project communication materials will continue in those relevant fairs or exhibitions where partner’s stands will be present.

Acquired knowledge and experience will be used as a basis to build up regional legislation or guidelines for the sustainable forest management. Furthermore, those beneficiaries have a specific rule in SFM, and biodiversity monitoring can apply directly the tools developed in the project (MRSM, SFS, UCCAS).
LIFE SySTEMiC is facilitating the development of science-based strategies, methods and recommendations also for policy-makers and managers at pan-European scale. Project has actively partecipated in forest policy initiative of eight, forest-focused LIFE projects in the Mediterranean area who have joined forces to align their outcomes with EU climate and biodiversity targets in the frame of the European Forest Strategy. We have co-produced the position paper “A step forward in EU forest policy: the Mediterranean perspective” and participated on forest policy roundtable in May 2022 in Brussels, to contribute EU policymaking towards sustainability.
In perspective, finalization of project’s outputs will add significantly to the possibilities for the transfer of policy recommendations for EU decision makers through International and National events (IUFRO congress, Brussels workshop, local stakeholder workshops in beneficiary countries) and publications.
Implementation of policy measures in each country depends on specific conditions and social capabilities based on existing national/local institutions, policies and laws.
In Croatia – support for forestry policies adaptation with the Croatian Ministry of Agriculture, the Forestry sector and national forest company, Croatian Forests Ltd. and particularly to working group for forest management planning, preparation of common management plans for Forest seed objects (FSO), preparation of guidelines for selection of FSO/plus trees in Croatia.
In Slovenia, results from project activities have been used to renew national forest regeneration approach and strategies for biodiversity conservation within regional forest management plans for period 2021 – 2030, adaptation of silvicultural and forest reproductive material operative policies and legislation, and for the development of forestry services within EU program Next Generation EU.
In Italy, support for implementation of National Forest Strategy (published in 2022) especially on the field of forest genetic resource conservation (Specific action 3 – Genetic resources and plant material, and sub-actions 3.1 Forestry nurseries, genetic resources and plant material; and 3.2 Oriented silvicultural management and assisted migration) – provision of new science-based information and practical experiences to support the decisions of forest policy makers at regional scale (e.g., in Tuscany Region), and used from Stakeholders of the SAB and responsible for forest management in protected areas (Foreste Casentinesi National Park, National Park of Sila, Biogenetic Nature Reserve of “Pian degli Ontani”).

The development of guidelines, practical Handbook, and GenBioSilvi model will further facilitate cooperation among foresters, conservationists, hunters and other end-users on implementation of forest genetic resources conservation into SFM.

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