**LIFE13 ENV/SI/000148**

**Short version of the Final Report**

**Covering the project activities from July 1st, 2014 to**

**December 31st, 2020**

**Reporting Date**

**June 15th, 2021**

**LIFE FOR FOREST GENETIC MONITORING SYSTEM**

**LIFEGENMON**

**Data Project**

|  |  |
| --- | --- |
| **Project location** | Slovenia; Germany, Greece |
| **Project start date:** | 1.7.2014 |
| **Project end date:** | 31.12.2020 |
| **Total budget** | Planned: 5,484,162€; spent: 5.167.464,49€ |
| **EC contribution:** | 2.576.967,24€ |
| **(%) of eligible costs** | 49.99% |

**Data Beneficiary**

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| --- | --- |
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### List of keywords

Biodiversity, Forest Genetic Resources, Indicators, Manual for Implementation, Demonstration Plots, Awareness raising

### List of abbreviations

SFI - Slovenian Forestry Institute

ASP - Bavarian Office for Forest Seeding and Planting

CNVOS – Centre for Information service, co-operation, and development of NGOs

AUTH - Aristotle University of Thessaloniki

GDDAY – DAMT - Decentralized Administration of Macedonia – Thrace

SFS - Slovenia Forest Service

RC – AUTH – Research Committee Aristotle University of Thessaloniki

GA – Grant Agreement

PA – Partnership agreement

LoC – Letter of Commitment

AB – Advisory Board

TB – Technical Board

NFP – National Focal Points

CBP – Coordinating Beneficiary Partner

ABP – Associated Beneficiary Partner

PC – Project coordinator (Prof. Dr. Hojka Kraigher)

PM – Project manager (Tjaša Baloh)

DM – Dissemination manager (Boris Rantaša)

FM – Financial manager (employed from April 2015; till then done by PM)

BL – Beneficiary leaders (Hojka Kraigher, Barbara Fussi, Veronika Vodlan, Phil Aravanopoulos, Nikitas Fragiskakis/Fotis Kiourtsis, Živan Veselič)

AL – Action leaders (Barbara Fussi, Phil Aravanopoulos, Monika Konnert, Gregor Božič, Marjana Westergren, Veronika Vodlan, Boris Rantaša, Urša Vilhar, Tjaša Baloh, Hojka Kraigher)

BAR – Beneficiary Action Responsible (see Organigramme)

BFM – Beneficiary Financial Manager, responsible for LIFEGENMON

SOP – Standard Operation Procedures

PM SOP – Project Management Standard Operation Procedures

FGM – Forest Genetic Monitoring

FGR – Forest Gene Resources

FRM – Forest Reproductive Material

DCU – Dynamic Conservation Units (Forest Gene Reserves)

EUFORGEN – European Forest Genetic Resources Programme

ICP – International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests

SNPs – Single nucleotide polymorphisms

TMO – Technical Monitoring Officer (NEEMO MR Nikolaj Pečenko)

RAP – Refined Action Plan

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# Executive summary

Sustainable forest management is based on the long-term adaptability of forest ecosystems and starts at the lowest, namely the gene level. Forest genetic monitoring (FGM) is therefore a crucial component of any sustainable forest management as it gives a possibility to detect potentially harmful changes of forest adaptability before they are seen on higher levels. Forest genetic resources face many increasing threats. By introducing genetic monitoring into conservation programmes and sustainable forest management one has the tool in hand to assess information on relevant changes of a species and/ or populations’ adaptive and neutral genetic variation through time. Based on indicators and their verifiers it can serve as an early warning system to aid the assessment of a species response to environmental change at a long-term temporal scale.

**The aims of the project**

* To define optimal indicators and verifiers for monitoring of genetic diversity changes in time across a transect from Bavaria to Greece for two selected target species, a stand forming broadleaf and a stand forming coniferous species;
* To prepare guidelines for forest genetic monitoring for these two and additional five forest trees species, which differ in their biology and distribution, for implementation of FGM at a national, regional and EU scale;
* To prepare a Manual for Forest Genetic Monitoring for implementation at the EU level;
* To prepare a Decision support system for an optimal choice of the level of FGM based on needs and means;
* To organize series of workshops / trainings for the forestry sector to be capable of implementing FGM according to standardized procedures in their territories;
* To prepare background professional documents / guidelines for policy makers at the national, regional and the EU level for supporting development of possible new regulations at the national level, the FOREST Europe process and future European Forestry and Biodiversity Conservation policies and strategies;
* To discuss and disseminate the FGM among different target audiences and stakeholders to promote the use and results of this early warning system as a tool for sustainable forest management;
* To establish a well-functioning, internationally linked team of forestry professionals working in and for FGM.

**Results of the project**

* Genetic monitoring regions delineated for 7 species / species complexes within the transect countries;
* Six genetic monitoring sites installed in three countries, two sites per country, one for Fagus sylvatica, one for Abies alba/Abies borisii-regis;
* Database for storing demographic & genetic data, including raw genetic data developed;
* Minimum & optimal number of indicators & verifiers defined for three monitoring levels (midterm and updated at the end of the project);
* Cost estimation of genetic monitoring per species / level / indicator assessed (as part of the Manual for forest genetic monitoring, common result of B1 and B2);
* Protocols for collecting demographic & genetic data standardised (midterm and updated in the end of the project, common result of B1 and B2);
* Species / species group specific guidelines and strategies for the European Forest Genetic Monitoring system established (7 guidelines);
* A written handbook entitled Manual for forest genetic monitoring published, containing practical advice on forest genetic monitoring including consequences for sustainable forest management;
* The Decision support system prepared.

Report on background documents to support the preparation of modifications of existing legislation and proposals for new regulations at the national and at the European scale has been facilitated, streamlined, and harmonized, based on the information and results generated by workshops involving stakeholders and policy makers.

The achieved goals of the actions provide a solid background for preparation of future strategies for application of Forest genetic monitoring to halt biodiversity loss at a Pan-European scale. Unified strategies will help to overcome methodological and political difficulties due to national initiatives (national specificities/characteristics).

Results of genetic monitoring will directly lead to practical forest management actions by using the detailed Decision support system, including a „Policy and Procedures“ section. The long-term development of range-wide conservation will be ensured by congruent European scale strategies for forest trees and by the implementation of a European wide Forest genetic monitoring system.

Access to all information sources can be obtained on the internet and/or in libraries. When appropriate, existing monitoring plots and data can be accessed via web-portals or data curators. If requested data shall be transferred to the European Forest Data Centre of the JRC of the EC, for public dissemination.

**Our project team and actions**

The project team was formed by 6 project partners from 3 countries: Germany, Greece, and Slovenia. The consortium is coordinated by Slovenian Forestry Institute (SFI), with associated beneficiaries Slovenia Forest Service (SFS), Centre for information service, co-operation and development of NGOs (CNVOS), Bavarian Office for Forest Genetics (AWG), Aristotle University of Thessaloniki and General Directorate of Forests and Agricultural Affairs – Decentralized Administration of Macedonia - Thrace (GDDAY-DAMT).

The actions comprised of Preparatory action (A), Implementation actions: Defining optimal indicators and verifiers (B1), Guidelines and management strategies (B2) and Policy guidelines (B3), monitoring action Impact and Project Monitoring(C), dissemination actions General Dissemination(D1) and Targeted Dissemination (D2) and management action dedicated to Advisory Board and Networking (E1) E2 Management Structure and Procedures (E2), After-LIFE Communication Plan (E3) and Final Audit (E4).

**General progress**

The project LIFEGENMON - LIFE for European Forest Genetic Monitoring System – has started with its highly intensive schedule on July 1st, 2014. The first Technical Board and Kick-off Advisory Board – Preparatory Action Meeting (part of **Preparatory Action A**) were organized in Teisendorf, Germany, in mid July 2014, when the Technical and Financial rules of LIFE projects were presented by the Coordinating Beneficiary Partner and accepted by all beneficiaries; also the Advisory Board was formed at the very beginning of the project, due to organisational activities starting already before the project contract was signed.

Immediately after the first AB meeting the transect drive from Bavaria to Greece was organized for BP representatives and led by the country representatives – national focal points (NFPs). The transect drive was of utmost importance for the project team to get first-hand information about the state of forests, forestry, forest legislation and the state of forest genetic resources in the region, in which forest genetic monitoring is to be proposed for implementation. However, since some partners could not join the July 2014 transect drive, and since not all countries / regions could be visited, a continuation of this drive was organized in early July 2015. During the July 2014 drive, ministry representatives from BiH and Serbia were met, and plots in BiH, Vojvodina, FYROM and Greece were visited. In July 2015, the ministry representatives from FYROM and Croatia were met, and plots in Central Serbia, eastern BiH, Croatia, Hungary and Slovenia were visited.

Closely linked to Preparatory Action A were all other actions, particularly E Management, and by M9 all management activities were already transferred to action E, including the organization of the 2nd AB meeting in early March 2015 in Thessaloniki, 3rd AB meeting in September 2016, while the 4th AB Meeting is scheduled in February, 2018. Technical Board Meetings are organised a day before Advisory Board Meeting.

ABP financial representatives and action responsible persons were defined, and reporting procedures between BPs and between CBP, the external evaluator and the LIFE Team were included into the Standard Operation Procedures for project management. These activities were done in close cooperation with the internal monitoring action C, led by ABP CNVOS. Furthermore, the project communication system (4th office), also needed for monitoring, was established.

The foreseen activities in action E were immediately well on the way, E1 Advisory Board and Networking action have enabled extensive cooperation at the transect area (NFP’s of Advisory Board), as well as FGM scientific community at the Pan-EU level (EUFORGEN SC representatives in Advisory Board), while E2 Project Management and Monitoring through day-to-day activities insured a smooth implementation of the 6 and half years and 5 mio EUR project consisting of over 30 implementation and over 25 dissemination and networking sub-tasks.

In Preparatory Action A, the list of national legislation for all countries from Germany to Greece, as well as European strategies and legislative documents important for forest genetic resources, were collected, a general overview of forest genetic monitoring regions was prepared, indicators and verifiers selected, potential monitoring plots in all three participating countries proposed, visited, and selected. The review paper “FOREST GENETIC MONITORING: AN OVERVIEW OF CONCEPTS AND DEFINITIONS” has been published in the Journal “Environmental Monitoring and Assessment”.

Within the Implementation Action B1, the project monitoring regions have been successfully defined and the selection of genetic monitoring sites for two species (*Fagus sylvatica, Abies alba/Abies borisii-regis* complex) has been successfully accomplished. Common protocols for demographic assessment have been determined and tested. Demographic assessment has been carried out. Phenology phases assessment has been ongoing on a yearly basis since the beginning of the project and continued until the project duration. Field sampling for DNA extraction has been completed (1st and 2nd project genetic monitoring assessment). Standardization of the genetic data across partners has been achieved through common protocols, sample standards and especially through the performance of successful ring tests. The initial selection of genetic parameters for the genetic monitoring indicators and verifiers has been completed and has led to the 1st and 2nd laboratory assessments and analyses of field samples which have also been completed. In total, 5100 samples have been analysed in silver fir and beech. All loci used for the genetic assessment were polymorphic. Some of the tested verifiers did not significantly differ among cohorts in both species, however in some others different results among studied cohorts within each population/FGM plot were detected. These results were compared against those of the 2nd assessment carried out in 2019, where 3350 samples were analysed, in order to fully evaluate the genetic monitoring results. In general, results are in line with other published studies of the same species within their distribution range and reveal ample genetic variation. SNP analysis was carried out as well including 168 SNPs 146 after filiering)/218 samples per country for beech and 267 SNPs (185 after filtering)/188 samples per country for fir. All of the above indicate the generation of a vast amount of data for which a database has been developed, its library has been discussed and finalized and the database itself has been deployed. Cost analysis, a complex and crucial exercise especially regarding the analytical description of costs and time requirements for all partners in the same manner, has been completed as well. Based on the cost assessment and the information capacity of different indicators and verifiers their final choice, as well as the development of a Decision Support system for genetic monitoring was also completed.

The implementation action B2 started in autumn 2015 with a review of existing concepts in FGM through a review paper. Second review paper was published in 2018 on existing forest management practices and monitoring sites. The standardization of protocols as part of the final FGM guidelines and Manual has been finalized and the optimisation for three different genetic monitoring levels was successfully finished. The established FGM protocols for field measurements and lab work was done for *Abies alba* and *Fagus sylvatica*, based on the activities and results collected from established six FGM sites in Slovenia, Germany and Greece. Following first results from B1 Action FGM protocols has been extended for the additional five target tree species within the LIFEGENMON project and Forest Genetic Monitoring (FGM) guidelines were established for seven target tree species/species complexes (*Abies alba/Abies borisii-regis* complex, F*agus sylvatica, Fraxinus excelsior, Pinus nigra, Populus nigra, Prunus avium, Quercus petraea/robur* complex). FGM guidelines provide concise guidance on how to select, establish and maintain forest genetic monitoring plots and on recording all field level verifiers and background information for different “model” tree species at different monitoring levels (basic, standard and advanced). Manual for FOREST GENETIC MONITORING containing practical advices on FGM implementation has been developed and published within the LIFEGENMON project. FGM Manual has been developed encompassing different monitoring intensities and cost levels. Three options or levels for FGM are proposed in the manual: Basic, Standard and Advanced. The FGM Manual is composed of nine chapters: 1. Introduction; 2. Plot selection; 3. Plot establishment and maintenance; 4 Indicators, verifiers and background information; 5. Fieldwork; 6. Laboratory and data analyses; 7. Cost assessment; 8. Decision support for selecting the intensity of FGM; 9. Guidelines for forest genetic monitoring. Overall the Manual contains practical advice, instructions and recommendations for carrying out all stages of genetic monitoring – from selection and establishment of monitoring plots to analysis and interpretation of data – are described within it, based on experience and findings accumulated during the project by the participating partners. Overall the FGM guidelines of the seven target tree species and FGM manual are expected to contribute to the establishment of a network of genetic monitoring plots across Europe for the early assessment of climate change impacts on the genetic variation of forest tree populations, so that their adaptive management can be implemented on time, efficiently and effectively.

The compilation of all cost estimation for different levels of FGM was a continuation of Action B1 and was finalised within Action B2 as a chapter 7 ″COST ASSESSMENT″ in FGM manual. The cost assessment present in this document is based on an analysis of the actual costs of activities carried out in the LIFEGENMON project. Each participating partner institution logged their costs, including material cost, outsourcing, travelling costs and cost of labour throughout the duration of the project. Costs were assessed per species/ country/monitoring level/ indicator/ verifier. The Decision support system was formulated following B1 Action (B1.2.1, B1.2.2 and B1.2.3) and widely discussed within B2 Action and finally has been completed in Action B3. Overall, the decision support system aims to help the policymakers with the choice of the best level of genetic monitoring (basic, standard and advanced) considering the questions to be answered and human and financial resources, as well as expertise, available at the local, national, regional and European scales.

Overall close cooperation with a Horizon2020 financed project GENTREE and [European Forest Genetic Resources Programme](http://www.euforgen.org/) (EUFORGEN) helped to promote genetic monitoring at the Pan-European scale. A number of training and workshops were organised on national levels with participation of foresters and experts that will implement the genetic monitoring. In addition, a number of workshops were organized within the transect countries for national focal points (NFP) (i.e in Serbia, Bosnia and Herzegovina (two entities), North Macedonia, Croatia) for foresters, scientists and officers involved in management and planning.

Action B3 has aimed at establishing communication with the policy makers to raise awareness on the importance of forest genetic monitoring, through discussion and preparation of an action plan and of background policy documents. It comprised three sub-actions: i) Formation of an action plan, ii) Preparation of draft professional background documents intended for submission to the responsible legislative national bodies / policy makers and iii) Preparation of background professional / expert documents for up-scaling of genetic monitoring from national to European scale. The work was done in close collaboration with the stakeholders and was supported by the NFPs and other experts. The inclusion of the stakeholders also among project partners helped to identify possible issues not considered in the compiled literature or existing legislation, resolutions and strategies, enabled direct communication and testing of proposed solutions, and created innovative ideas for better future strategies and legislation. The communication action plan was prepared as a flexible outline so as to adapt to development and circumstances at the national level and has been further operationalized throughout the project duration through the constant interaction - discussion with policy makers: The discussion with the policy makers (i.e. regular meetings with the nominated committees and representatives at the Ministry of agriculture, food and forestry in Slovenia, the regular monthly meetings of the director of project partner AWG with the Bavarian ministry, responsible for forests, and the combined role of the partner GDDAY DAMT as a forestry service and a decentralized forest ministry and communication with the Hellenic national ministry) was increasing awareness towards the importance and implications of genetic monitoring. The needs for and advantages of genetic monitoring have been presented and discussed at the EC DG SANTE WG on FRM in Arcachon, and later on in 2018 organized in Slovenia with support of the LIFEGENMON team, at the SC EUFORGEN meetings, while representatives of policy makers also attended a Stakeholders’ event on genetic monitoring in Thessaloniki, in 2017. Furthermore the need for FGM and presentation of the LIFEGENMON project have been included into the Forest Europe meeting in Košice, SK, 2018, COP24 in Katowice, IUFRO congresses in 2017 in Germany and 2019 in Brazil, the common stakeholders’ meeting in Brussels in 2019 (4 projects + EUFORGEN programme) for representatives from DG SANTE, ENV, CLIMA, AGRI, RID and others, and well as in a number of other meetings aimed at policy and decision makers at the national and international scales. The requirements for implementation of FGM were included in several EU projects: the Horizon projects, such as GENRES BRIDGE and FORGENIUS the LIFE projects, such as LIFE SySTEMiC, INTERREG projects, and into national and international strategies and legislation, such as the European genetic resources programme. Additionally, a new thematic session was established within IUFRO: session [2.04.12 - Forest genetic monitoring](https://www.iufro.org/science/divisions/division-2/20000/20400/20412/).

Monitoring activities started as planned on the 1st of July 2014 by setting up monitoring matrix and protocol as a foundation for monitoring of all project activities and impact. The documents were prepared by T. Michieli and T. Divjak and then revised when V. Vodlan took over day-to-day monitoring of the project in April 2015.

Monitoring of the project was done on a regular basis and special technical meetings with PC, PM and/or AL as well as AB members were organized (face-to-face when possible and by Skype). Due to a big amount of dissemination events Vodlan became part of the Dissemination team and is included in all communication. This enabled her to constantly follow the progress made and to provide consultancy and possible improvements when activities were still in the preparation phase. The monitoring of other Actions was done by regular meetings (Skype and face-to-face) with Action Leaders and other staff involved in the implementation.

The actions with most activities planned and carried out were the Dissemination actions, led by the Dissemination Manager (DM), and corresponding ABP responsible persons. The home page is fully operational and highly visible (the website counter shows over 36.000 visits), the project leaflets, newsletters and E-news were published and distributed, notice boards were printed in English and the three national languages and posted on the plots, the lists of media contacts in the three project countries were obtained, and the activities within the refined action plan are in progress. Workshops for children, training courses for teachers, teaching materials and children’s books reached huge general public interest. Also several internal workshops were organized for specialists doing forest inventory, forest owners, users of FRM, tree dealers, seed dealers, silviculturists and forest managers in all project countries, in addition to workshops and scientific conferences for forest management, silviculture, forest genetic and legislative and governance events to promote forest genetic monitoring, forests and forestry to the target audiences and stakeholders at different levels.

A large share of the LIFEGENMON project was dedicated to communication and dissemination activities. The aims and results of the project with regards to the LIFE requirements were communicated and disseminated to the general public and to specific target groups with different approaches. The general public was informed about the importance of forests' ability to adopt to the changing climate and the role of FGM through films, videos, festivals, events, fairs, social media (Facebook, Twitter & Linkedin) and even through a smartphone app called Seedhunter. All these activities contributed to understanding of the importance of genetic monitoring or genetic diversity among people that are not familiar with a concept/topic. The acquired knowledge enables the public to make better informed everyday decisions and exercise pressure on policy makers if needed. A special focus of the communication activities was put on education for children, workshops and events that contribute to a respectful attitude towards forests from an early age.

The scientific community, forestry professionals, nurseries, forest owners and policy makers were, however, addressed mainly through workshops, publications and presentations. These activities have supported the project objective to develop measures for adaptive forest management based on genetic forest protection. They have encouraged knowledge exchange within and between the project partner countries and other European countries. Cooperation with other European projects, networks and programs enabled us to reach a very wide audience. All the objectives and deliverables have been reached.

The project objectives and the work plan have been shown as most relevant, and the project as well as the concept of developing the system for forest genetic monitoring have already received large attention in the region and within the European forestry, nature conservation and other communities.

# Introduction

## Description of background, problem, and objectives

**Environmental problem/issue addressed**

Forest genetic resources face many increasing threats despite the overall forested area remaining rather stable (European Environmental Agency (EEA) 2010). Climate change, air pollution, unsustainable forest management, invasive species, urbanization, and forest fragmentation reduce forest biodiversity, may adversely affect genetic diversity and put at threat the future adaptive potential and sustainability of European forests. To ensure the maintenance of genetic variation in natural forest tree populations an early warning system is needed, as subtle but significant adverse changes may not be visible to the naked eye for years. Genetic monitoring is destined to do just that.

**Outline the hypothesis to be demonstrated / verified by the project**

Several studies have defined the need of genetic monitoring in order to quantify relevant changes regarding long-term adaptability of a species (Aravanopoulos 2011), or to assess the dynamics of transition from the present to the future genetic status of a forest stand (Konnert et al. 2011). Genetic monitoring enables the observation of temporal changes in populations and therefore relevant components can be inferred and consequences evaluated. Hence, genetic monitoring includes a prognostic value as well and forms a method to secure the conservation of processes that maintain genetic variation in natural populations (Aravanopoulos 2011).

**Description of the technical / methodological solution**

* Review of national legislation for all countries from Germany to Greece and European strategies and legislative documents important for forest genetic resources were collected.
* Common protocols for demographic assessment have been determined and tested.
* Phenology phases assessment has been ongoing on a yearly basis since the beginning of the project and continued until the project duration.
* Field sampling for DNA extraction has been completed (1st and 2nd project genetic monitoring assessment).
* Standardization of the genetic data across partners has been achieved through common protocols, sample standards and especially through the performance of successful ring tests.
* Comparing results in 2020 against those of the 2nd assessment carried out in 2019, SNP analysis was carried out as well including 168 SNPs 146 after filtering)/218 samples per country for beech and 267 SNPs (185 after filtering)/188 samples per country for fir.

All of the above indicate the generation of a vast amount of data for which a database has been developed, its library has been discussed and finalized and the database itself has been deployed.

Cost analysis, a complex and crucial exercise especially regarding the analytical description of costs and time requirements for all partners in the same manner, has been completed as well. Each project partner logged their costs, including material cost, outsourcing, travelling costs and cost of labour throughout the duration of the project. Costs were assessed per species/country/monitoring level/ indicator/ verifier. The standardization of protocols as part of the final FGM guidelines and Manual optimisation for three different genetic monitoring levels was successfully finished.

The established FGM protocols for field measurements and lab work was done for *Abies alba* and *Fagus sylvatica*, based on the activities and results collected from established six FGM sites in Slovenia, Germany and Greece. FGM protocols have been extended for the additional five target tree species within the LIFEGENMON project and FGM guidelines were established for seven target tree species/species complexes (*Abies alba/Abies borisii-regis complex, Fagus sylvatica, Fraxinus excelsior, Pinus nigra, Populus nigra, Prunus avium, Quercus petraea/robur complex*) and Manual for FOREST GENETIC MONITORING containing practical advice on FGM implementation was published.

Throughout the project a close cooperation with a Horizon2020 financed project GENTREE and [European Forest Genetic Resources Programme](http://www.euforgen.org/) (EUFORGEN) helped to promote genetic monitoring at the Pan-European scale. Several training and workshops were organised on national levels with participation of foresters and experts that will implement the genetic monitoring. Continuous communication with various policy makers helped raise awareness on the importance of forest genetic monitoring. The needs for and advantages of genetic monitoring have been presented and discussed at the EC DG SANTE WG on Forest Reproductive Material in Arcachon.

Monitoring activities of project implementation have been carried out throughout the project by the internal monitoring team at partner CNVOS.

**Expected results and environmental benefits**

The project has prepared the Forest Genetic Monitoring Manual and Guidelines for 7 species and set up demonstration monitoring plots in three countries. Through this the project contributes to mitigation and assists with the adaptation of EUROPEAN forests to climate change. In particular, the Manual and Guidelines for FGM have been developed encompassing different monitoring intensities and cost levels. Moreover, the Decision Support System has been developed to aid policymakers in choosing the optimal level of FGM considering the costs and benefits of different levels. Additionally, this system provides recommendations for implementation of measures for conservation and sustainable use of FGR in the changing climate. The Manual is based on sound theoretical genetic monitoring principles, however as FGM is a long-term effort, it can only reach its full potential after a sufficient number of temporal assessments will have been performed. Like any analytical system, the proposed FGM system will need to be continuously assessed and evaluated to see if it is meeting the expected monitoring objectives, and if improvement or redesign is needed (Fussi *et al.* 2016).

**Expected long term results**

In a long term FGM shall allow an improved adaptive forest management system to enhance the resilience of forests to climate change. Resilient forests will be better able to continue to provide ecosystem services expected by the society alongside harbouring, facilitating and enhancing the conservation of biodiversity. The current results will facilitate an anticipated future trajectory from genetic to genomic monitoring, which is expected to increase precision in estimates of population genetic diversity and adaptive genetic potential.

# Technical part per action

## 4.1. Technical progress per task

### A1: Screening

A1.1 Define national focal points (NFP) – experts to be invited to workshops and representing selected countries in the transect from Bavarian Alps to Olympus

The list of national focal points has been completed and available in the report of 2014. A Letter of Commitment (LoC) has been signed with all the NCPs regarding their participation at the AB meetings, and their contribution to the project. The NFPs have been involved with their expert advice in all implementation actions, contributing also to actions D and E1.

Two transect drives have been carried out, organised by project coordinator with participation of all project partners, as approved by EC in the Inception report. First in July 2014 from Germany to Greece and the continuation of the transect drive from Skopje to Ljubljana from 28th of June 2015 to 4th of July 2015.

A1.2 Compile national policies and European regulations and any other relevant documents at the European and national scale

The national policies of transect countries have been compiled. A list of European regulations has been prepared.

A1.3 Collect information on existing plots within the transect, including EUFGIS DCU, ICP level I, II, ICOS sites, ManFor CBD and any existing ‘super sites’, etc., their characteristics, data collection per plot, management, financing schemes, and permanence

Collection of information was done. Access to relevant databases was established.

Information (data standards and minimum requirements) for EUFGIS DCU are given in Koskela et al. 2013 and Lefèvre et al. 2013. At finalization of the Preparation Action A there were 120 DGCU for *Fagus sylvatica* within the transect (Austria 78, BiH 13, Croatia 3, Germany 22, Serbia 1, Slovenia 4), 110 for *Abies alba* (Austria 75, BiH 18, Croatia 4, Germany 8, Serbia 1, Slovenia 3) and 4 for A. *borisii regis* (FYR Macedonia 1, Greece 3). Other existing monitoring plots within the project (ICP, ManForCBD, ICOS) have been identified per country level, the information was reviewed within action B2.

### A2: Definitions and concepts

A2.1 Compile an overview of definitions and concepts in genetic monitoring

Compilation of definitions and concepts and relevant literature has been performed and made available as a bibliography divided by relevant topics. The Review paper of definitions and concepts in genetic monitoring has been submitted to the Journal “Environmental Monitoring and Assessment” and has been accepted for publication. It appeared online in July 2016. See A2.4.

A2.2 Compile an overview of possible vegetation / ecological zones to be applied and considered in the transect

Overview of possible vegetation/ecological zones has been compiled.

A2.3 Compile an overview of considerations regarding the choice of tree species for preparation of genetic monitoring criteria

Concepts for consideration regarding the choice of tree species for genetic monitoring have been reviewed and decided on.

A2.4 Output: prepare an overview of definitions and concepts

Review paper[[1]](#footnote-2) has been accepted for publication. The Review paper was submitted to a special journal for Monitoring "Environmental Monitoring and Assessment" (http://link.springer.com/journal/10661). The main reason to prefer an international outreach of the journal over a regional impact since it is a topic relevant for European and world-wide forest ecosystems.

### A3: Complement the initial phase of the Management actions

A3.1 Refine the Technical coordination of the project and standardize management according to LIFE+

All activities transferred to action E Project Management and finalized.

A3.2 Establish the Advisory Board (AB) based on consultation with stakeholders in three countries (Greece, Germany, Slovenia)

The Advisory Board was established, roles defined, and financing of external experts clarified within Letters of Commitment (LoC).

A3.3 Initialize a database of experts, stakeholders, and end-users at a national and international level

The database has been initialized during the first AB meeting and the report submitted to the external evaluator.

A3.4 Output: AB established

Report including the refined action plan has been prepared: E1\_D1 – Report including the refined action plan and submitted in Progress report.

### B1: Defining of optimal criteria and indicators

Action summary according to expected results

Within the Implementation Action B1, the project monitoring regions have been successfully defined and the selection of genetic monitoring sites for two species (*Fagus sylvatica, Abies alba/Abies borisii-regis* complex) has been successfully accomplished. Common protocols for demographic assessment have been determined and tested. Demographic assessment has been carried out. Phenology phases assessment has been ongoing on a yearly basis since the beginning of the project and continued until the project duration. Field sampling for DNA extraction has been completed (1st and 2nd project genetic monitoring assessment). Standardization of the genetic data across partners, has been achieved through common protocols, sample standards and especially through the performance of successful ring tests. The initial selection of genetic parameters for the genetic monitoring indicators and verifiers has been completed and has led to the 1st and 2nd laboratory assessments and analyses of field samples which have also been completed. In total, 5100 samples have been analysed in silver fir and beech. All loci used for the genetic assessment were polymorphic. Some of the tested verifiers did not significantly differ among cohorts in both species, however in some others different results among studied cohorts within each population/FGM plot were detected. These results were compared against those of the 2nd assessment carried out in 2019, where 3350 samples were analysed, in order to evaluate fully the genetic monitoring results. In general, results are in line with other published studies of the same species within their distribution range and reveal ample genetic variation. SNP analysis was carried out as well including 168 SNPs 146 after filiering)/218 samples per country for beech and 267 SNPs (185 after filtering)/188 samples per country for fir. All of the above indicate the generation of a vast amount of data for which a database has been developed, its library has been discussed and finalized and the database itself has been deployed. Cost analysis, a complex and crucial exercise especially regarding the analytical description of costs and time requirements for all partners in the same manner, has been completed as well. Based on the cost assessment and the information capacity of different indicators and verifiers their final choice, as well as the development of a Decision Support system for genetic monitoring was also completed.

Action B1 started in January 2015 based on the Preparatory Action A activities and comprises of two sub-actions.

B1.1. Testing of indicators

Data regarding monitoring regions (for better understanding the 2nd TB decision was to change areas to regions) for seven keystone tree species (*Fagus sylvatica, Populus nigra, Fraxinus excelsior, Abies alba/Abies borisii-regis* complex, *Pinus nigra, Prunus avium, Quercus petraea/**robur* complex), were compiled so that monitoring regions could be defined for each country participating in transect from Bavarian Alps to Mt. Olympus. The crucial cooperation of the NFPs has been verified during the 2nd AB meeting.

Definition of monitoring regions was successfully accomplished.

The selection of genetic monitoring sites for two species (*Fagus sylvatica, Abies alba/Abies borisii-regis*), has been carried out taking into account already proposed monitoring regions. Selection of genetic monitoring sites for two species was successfully accomplished for all partners regarding *Fagus sylvatica* and *Abies alba/Abies borisii-regis*.

The establishment of FGM sites was done in April 2015 – June 2015 (M10-12) and was centred in obtaining field measurements of selected trees in both species in the relevant sites. Demographic assessment that includes age and size class distribution, regeneration abundance, and phenology, would be monitored throughout the project (flushing, flowering etc.). Assessed for the first time for two species (repeated in 2019) and is being further developed in action B2 also for the other five species. Protocols were prepared for phenology phases of both species.[[2]](#footnote-3) Demographic assessment for size class distribution, regeneration abundance and phenology (for 2016 and 2017) has been accomplished and relevant data have been collected by all partners.

Field samplings were done in May 2015 – August 2015 (M11-14) and have been repeated by August 2019 as planned in the proposal.

Laboratory assessment: overall results indicated generally comparable levels of genetic diversity between adults and natural regeneration and between the two assessments (2015, 2019). The effective (Ne) was generally above the Ne=50 threshold, but generally below a recently recommended threshold of Ne=500.

SNP analysis (data acquisition via outsourcing) of both *Fagus* *sylvatica* and *Abies borisii-regis* has been completed, and data analysis (in-house) has been completed as well for AWG, AUTH and SFI. Results were generally in acordance to the results acquired by the SSR analysis both regarding genetic diversity and effective population size.

For AWG, AUTH, GDDAY-DAMT and SFI, phenology observations for period 2016-2020 were completed for both *Fagus* *sylvatica* and *Abies borisii-regis* as planned.

In total 1050 samples per species per country were used for FGM study based on nSSR markers.

The silver fir genome was sequenced and the first draft has been published. Two partners from LIFEGENMON (SFI, AWG) have joined the group and participated in the publication. One partner (AUTH) joined later, the silver fir sequencing consortium and has participated in further sequencing efforts of the silver fir genome.

Field sampling: sampling methodology comparative test

During the LIFGENMON first genetic monitoring plot assessment, the discussion of sampling representativeness emerged regarding the number and spatial distribution of selected adult trees and selected natural regeneration seedlings and saplings, therefore we have agreed to test a complementary sampling design on one plot per species. Such design consisted of a high number of circular sub-plots, equally distributed along the plot in all directions. This assessment was performed for one species (*Fagus sylvatica*) and in one population (in Slovenia), to define the protocol. Based on the new assessment and the comparisons made with the original one, a modified FGM plot design was devised that is described in detail in the Manual. This briefly entails the analysis of 50 trees in a circular plot for stand forming species.

B1.2 Selection and valorisation of indicators

FGM manual Chapter 7 “COST ASSESSMENT” presents the costs associated with implementation of forest genetic monitoring. The cost assessment presented in this document was based on an analysis of the actual costs of activities carried out in the LIFEGENMON project. Costs assessment is divided in three basic categories: 1) Material costs, 2) Cost of labour (effective work) and 3) Cost of travel. Costs were assessed per species/country/monitoring level/indicator/verifier.

B1.2.2 Indicators and criteria for further implementation

FGM manual Chapter 4 “INDICATORS, VERIFIERS and BACKGROUND INFORMATION” presents three indicators selected for FGM: (1) natural selection, (2) genetic variation per se where the evaluation of genetic drift is incorporated as well, and (3) gene flow / mating system. The number of verifiers per indicator ranges (at three levels: basic, standard and advanced), from what is considered as the absolute minimum needed (key verifiers) for the assessment of an indicator, to the most comprehensive (optimal) evaluation where all verifiers are included.

B1.2.3. Development of a draft Decision Support System.

FGM manual Chapter 8 “DECISION SUPPORT FOR SELECTING THE INTENSITY OF FGM” presents the Decision Support Systemwhich aims to help policymakers choosing the best level of genetic monitoring (basic, standard and advanced), while considering the scientific questions to be answered, human and financial resources, as well as expertise, available at the local, national, regional and European scales.

B1.2.4 Standardization of demographic data

Common protocols have been determined, tested, and applied.

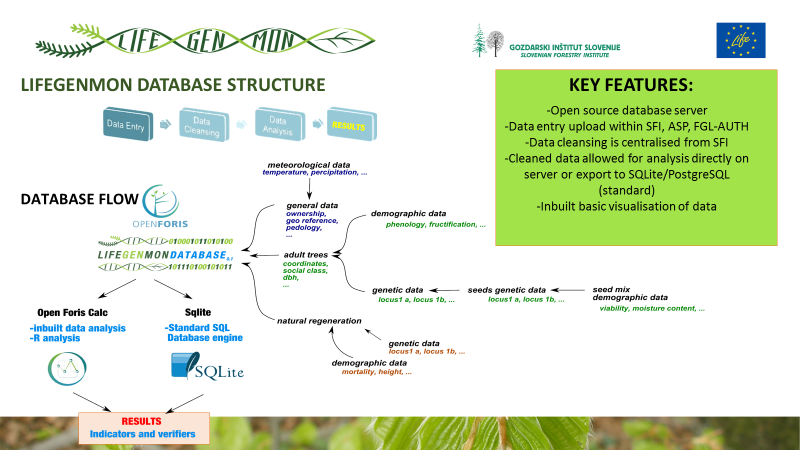
B1.2.5 Standardization of genetic data.

Standardization of genetic data has been achieved through common protocols, sample standards and the performance of ring tests. The partners exchanged and tested several protocols and samples. The implementation of the standardized common genetic data acquisition protocols has been successful. Relevant progress has been presented and discussed at the AB3 meeting.

The organization of technical specifications and the harmonization of genetic markers have been completed. A series of successful ring tests has been performed by all partners. The final choice of microsatellite primers and genetic loci that were later used in the genetic monitoring analysis has been made for both species. As a result, these markers are now safely being used for genetic monitoring across laboratories for both species. Two primers for *Abies* have been proven problematic during the ring tests and therefore their removal from the relevant list of *Abies* primers has been suggested and accepted by the Project consortium. This is not considered to be a major issue for the *Abies* genetic monitoring as there are still eleven stable and repeatable primers across laboratories. Observed differences in allele sizing between laboratories appear to depend on a complex set of factors that cannot be explained purely as a systematic error due to hardware/consumables-induced variation. Dyes have a pronounced effect on DNA migration by size/sterical interference and electrical charge effects. The combined effects on DNA migration appear to be at least in some cases marker- and fragment size-dependent. Evidently, no extrapolation of results to new markers is possible (i.e., every new marker must be ring-tested by all participating laboratories for the results to be comparable). Besides laboratory work protocols, ring test protocols should be included in the „FGM manual “. Any laboratory wishing to join the FGM system must undergo ring-testing to have inter-comparable results This exercise has shown the high validity of ring tests when performing genetic monitoring in multiple laboratories. A relevant manuscript on the actual ring tests, their results, and their value, is in preparation. Relevant progress has been presented and discussed at the AB3 meeting.

B1.2.6 Database for genetic monitoring

A suitable database structure for genetic monitoring data has been developed. The EUFGIS database and any other relevant databases in operation are also considered in its development. Currently there are 33145 data entries ready to browse by data owners (SFI, SFS, AWG, AUTH, GDDAY-DAMT). Further development and population of the database has been completed.



### 

### B2: Preparation of Guidelines and Management Strategy

**Action summary according to expected results**

Overall all expected aims and results within B2 Action were successfully achieved e.g.:

Forest Genetic Monitoring (FGM) guidelines for seven target tree species/species complexes (*Abies alba/Abies borisii-regis* complex, *Fagus sylvatica, Fraxinus excelsior, Pinus nigra, Populus nigra, Prunus avium, Quercus petraea/robur* complex) were developed and are presented in FGM manual chapter 9. All costs regarding forest genetic monitoring implementation were assessed and are presented in FGM manual chapter 7. Each participating partner institution logged their costs, including material cost, outsourcing, travelling costs and cost of labour throughout the duration of the project. Costs were divided in three basic categories: 1) Material costs, 2) Cost of labour (effective work) and 3) Cost of travel. Costs were assessed per species/country/monitoring level/indicator/verifier.

All protocols needed for collecting demographic and genetic data needed for FGM implementation were standardised. Protocols for FGM plot selection, establishment, sampling, phenology observations, molecular and demographic data analysis are present in several FGM manual chapters e.g. chapter 2, 3, 4, 5, and 6. In addition standardised protocols for target tree species plot establishment and phenology assessment are included in FGM species guidelines.

At the end based on collected data and performed activities within LIFEGENMON project a Forest Genetic Monitoring (FGM) manual was developed and published. Overall manual contains concise guidance on how to select, establish and maintain forest genetic monitoring plots and how to conduct FGM at different monitoring levels (basic, standard and advanced) at the European level. In addition, FGM manual Chapter 8 presents Decision support system “DECISION SUPPORT FOR SELECTING THE INTENSITY OF FGM” which aims to help the policymakers with the choose of the best level of genetic monitoring (basic, standard and advanced) considering the questions to be answered and human and financial resources, as well as expertise, available at the local, national, regional and European scales.

The implementation action B2 started in autumn 2015 following B1 Action activities and comprises the three sub-actions.

B2.1 Establishing guidelines and B2.2 Preparation of the Manual for forest genetic monitoring

### B3: Policy Guidelines

**Action summary according to expected results**

Action B3 has aimed at establishing communication with the policy makers to raise awareness on the importance of forest genetic monitoring, through discussion and preparation of an action plan and of background policy documents. It comprised three sub-actions: i) Formation of an action plan, ii) Preparation of draft professional background documents intended for submission to the responsible legislative national bodies / policy makers and iii) Preparation of background professional / expert documents for up-scaling of genetic monitoring from national to European scale. The work was done in close collaboration with the stakeholders and was supported by the NFPs and other experts. The inclusion of the stakeholders also among project partners helped to identify possible issues not considered in the compiled literature or existing legislation, resolutions and strategies, enabled direct communication and testing of proposed solutions, and created innovative ideas for better future strategies and legislation. The communication action plan was prepared as a flexible outline so as to adapt to development and circumstances at the national level and has been further operationalized throughout the project duration through the constant interaction - discussion with policy makers: The discussion with the policy makers (i.e. regular meetings with the nominated committees and representatives at the Ministry of agriculture, food and forestry in Slovenia, the regular monthly meetings of the director of project partner AWG with the Bavarian ministry, responsible for forests, and the combined role of the partner GDDAY DAMT as a forestry service and a decentralized forest ministry and communication with the Hellenic national ministry) was increasing awareness towards the importance and implications of genetic monitoring. The needs for and advantages of genetic monitoring have been presented and discussed at the EC DG SANTE WG on FRM in Arcachon, and later on in 2018 organized in Slovenia with support of the LIFEGENMON team, at the SC EUFORGEN meetings, while representatives of policy makers also attended a Stakeholders’ event on genetic monitoring in Thessaloniki, in 2017. Furthermore the need for FGM and presentation of the LIFEGENMON project have been included into the Forest Europe meeting in Košice, SK, 2018, COP24 in Katowice, IUFRO congresses in 2017 in Germany and 2019 in Brazil, the common stakeholders’ meeting in Brussels on 13.12.2019 (4 projects + EUFORGEN programme) for representatives from DG SANTE, ENV, CLIMA, AGRI, RID and others, and well as in a number of other meetings aimed at policy and decision makers at the national and international scales. The requirements for implementation of FGM were included in several EU projects: the Horizon projects, such as GENRES BRIDGE and FORGENIUS the LIFE projects, such as LIFE SySTEMiC, INTERREG projects, and into national and international strategies and legislation, such as the European genetic resources programme. Additionally, a new thematic session was established within IUFRO: session [2.04.12 - Forest genetic monitoring](https://www.iufro.org/science/divisions/division-2/20000/20400/20412/). The action has obtained all milestones and deliverables.

The action has started in January 2016 and comprised of three sub-actions:

1. Formation of an actions plan: it was done as a case for Slovenia and defined as a flexible document, to be adapted to the national and temporal circumstances; it has been further implemented in the other two partner countries at the regional level and considered for implementation in the transect countries with the continuous support and active contributions by all NFPs.
2. Preparation of draft professional background documents intended for submission to the responsible legislative national bodies / policy makers: at the national level the possibilities for modification of existing legislation has been discussed, and after a series of events the first modification of a one of the regulations in Slovenia has already been proposed and accepted (the Regulation on the regions of provenances); and genetic diversity has been included as a component to consider in forest management planning.
3. Preparation of background professional / expert documents for up-scaling of genetic monitoring from national to European scale: the activities consisted of communication events at different levels, also greatly supported by all members of the AB, and including a direct communication with the OECD and DG SANTE working groups on FRM in 2017 in France and organization of their meeting in Slovenia in 2018 with a special emphasis on FGM.

Expert collaboration: This work was done in close collaboration with the stakeholders, supported by the NFPs and other experts (see Actions A, B2, D2 and E1). The inclusion of the stakeholders helped to identify possible issues not considered in the compiled literature or existing legislation, resolutions, and strategies, and creates innovative ideas for better future strategic and legislative solutions.

B3.1 Formation of an action plan

Identification of communication systems with key stakeholders and policy makers and a formation of an action plan on the procedures needed to obtain a discussion line with policy makers was based on the Slovenian case study and is being continuously updated taking into consideration national, regional and EU heterogeneity. The action plan was also discussed at the stakeholder workshop in Thessaloniki which contributed to identification of modifications per country.

To communicate the possibility of forest genetic monitoring for monitoring of the vulnerability of marginal and peripheral populations, the following contribution was presented on the Joint Final Conference of the COST ACTION FP 1201 MaP FGR, EUFORGEN and IUFRO WG 20213 in 2016 in Arezzo, Italy: Life for forest genetic monitoring: an opportunity to monitor marginal forest tree populations in Greece. Authors: Aravanopoulos F., Avramidou E., Malliarou E., Tourvas N., Ganopoulos I., Alizoti P., Barbas E., Bekiaroglou P., Hasilidis P., Roussakis G., Kiourtsis F., Fragiskakis N., Westergren M., Fussi B., Konnert M., Kraigher H.

The results from the Report on the FGM problems at different scales were presented on the session on genetic monitoring at 125th Anniversary Congress IUFRO in September 2017. The session was co-organised by the LIFEGENMON project team (SFI, SFS, FGL AUTH, ASP) and was attended by over 60 scientists and forest professionals from all over the world. Title of the presentation within B3: Conservation and management of forest genetic resources: overview on forest policies in countries of South Eastern Europe. Authorship: Stojnić S., Stevanov M., Alizoti P., Andonovski V., Avramidou E., Ballian D., Božič G., Ivanković M., Georgiadou M., Hasilidis P., Orlović S., Stijović A., Toromani E., Westergren M., Kraigher H.

In 2019 the session was organized at the IUFRO World congress in Brazil, with a number of presentations; the year has ended with a well promoted and participated stakeholders’ event , as a combined networking event among 4 projects and the EUFORGEN programme, on 13. December 2019 in Brussels.

In 2020 the final conference ended with a round table discussion and a press conference aiming mainly at communication of the needs for implementation of FGM at the national, regional and international scales. The science-policy interface was well implemented, leading to an active After LIFE action & communication plan.

B3.2 Preparation of draft professional background documents intended for submission to the responsible legislative national bodies / policy makers

Along with the crucially important trainings for different groups of professional stakeholders, the SFS prepared the Guidelines for forestry practitioners (**Guidelines for monitoring and conservation of genetic diversity**, **Guidelines for providing forest reproductive material**) in Slovene language, both as detailed documents and summarized as leaflets for daily use in the field. Both have been distributed widely within the professional community and are going to be continuously used in future professional activities.

In Slovenia, the LIFEGENMON project played a key role in raising awareness and developing solutions in the field of conservation and management of forest genetic diversity and forest reproductive material. The project team at the SFI and SFS will continue to explore and act on possibilities for the continuation of implementation of a forest genetic monitoring system on the highest level possible. The LIFEGENMON project also helped facilitate the digitalisation of forest monitoring in Slovenia. Forest monitoring application has been prepared and is being used by the SFS: **Application for tracking the success of artificial forest regeneration**, **Application for monitoring of fructification**

Professional background documents (in Slovenia only) have been conceptualized, based on the already accepted modification of the regulation on delineation of provenance regions in Slovenia (accepted in December 2017), and concentrated in the discussion-line with the SFS and the ministry representatives.

In Germany, previous projects together with the LIFEGENMON played an important role in raising awareness and developing FGM in Bavaria and Germany. Already now we can see the continuation of implementation of a forest genetic monitoring system in Bavaria. Permanent long term monitoring has through the two projects become part of the routine work of AWG and is financed by the Bavarian Ministry.

In Greece there have been several developments with regards to raising awareness and developing solutions in the field of conservation and management of forest genetic diversity. The existing FGM actions in Greece confirm the importance of the topic and show a clear need and mandate for forest genetic monitoring (FGM), especially under the climate change. Therefore, a proposal has been prepared to integrate the FGM protocols to the existing Forest Management Plans, in accordance with current legislation, the environmental economy and the selected FMP objectives is ongoing in order to ensure continuity of FGM through permanent financial support of long term genetic monitoring activities. The discussions with Ministry Environment & Energy officials improved the understanding of high-level administration for FGM and there is a scheme to develop specific national documentation for FGM establishment, as part of the “AfterLife” plan.

B3.3 Preparation of background professional / expert documents for up-scaling of genetic monitoring from national to European scale

The activities started in June 2016 with preparation of the proposal to the IUFRO 125th Anniversary Congress and organisation of a special session dedicated to the biodiversity (FGM) science-policy interface worldwide. Preparation of the documents for upscaling of genetic monitoring from national to European scale has started with the discussions in several groups and a plenary setting on the stakeholder’s workshop in Thessaloniki in 2017, with the input from advisory board members, policy makers from Greece, foresters that will be directly in charge of the implementation of the monitoring itself and researchers from a complimentary research project GenTree.

Highlighted activities:

* A dedicated session was organised and a key-note presentation given at the 125th Anniversary IUFRO congress in Freiburg.
* A combined 5-projects stakeholders’ event was organized in December 2018 in Brussels, attended by representatives of several DGs and NGOs.
* A dedicated session and several presentations were given at the regular IUFRO congress in 2019 in Brazil.
* A thematic issue of the journal Forests, and another one for the journal Frontiers in Plant Sciences, were co-edited within the LIFEGENMON project.
* A new IUFRO session on Forest genetic monitoring was accepted and started in 2020, coordinated by the LIFEGENMON team. The vice.chair of the Division 2 on forest genetics and physiology is a member of the LIFEGENMON team.
* Several summer training schools were organized for promotion of FGR conservation and for implementation of FGM.
* Representatives from the LIFEGENMON team were actively included and contributed to the task group EUFORGEN on preparation of the new EUFORGEN FGR Strategy (draft circulated within the EUFORGEN community, with FGM included among recommendations).
* Representatives from the LIFEGENMON team included in the EUFORGEN report on the Decision support tool (see [www.euforgen.org](http://www.euforgen.org)).
* Representatives from the LIFEGENMON team were included in the EUFORGEN report on genetic aspects of FRM production and use (draft circulated among the EUFORGEN community).

Generally, a link with the EUFORGEN programme was strengthened to pursue a common strategy to address the policy makers, also, Greece is again a member of EUFORGEN, and several LIFEGENMON team members (namely H. Kraigher, M. Westergren and F. Aravanopoulos) were actively contributing to the FGR strategy preparation and the two EUFORGEN reports.

Several regional projects and collaborations have been proposed, some accepted, with other countries, including a LIFE project LIFE SySTEMiC focusing on developing standardized protocols for close-to-nature management, maintaining the biodiversity, and significantly reducing the genetic erosion of target forestry (I-SI-CRO).

### C: Monitoring of the impact of the project actions

The monitoring protocol that was developed at the beginning of the project was updated and revised to reflect the changes reported in the Refined Action Plan. The most significant changes appeared in the Action D – Communication and dissemination. This is the most diverse action of the project where there are lots of deliverables and in the process of project implementation possibilities for bigger impact were identified. Therefore, the activities were adopted according to these identified opportunities to make sure the biggest possible impact of the intervention. During technical meetings with the Action D Leader, coherent project monitoring tools were developed and finalized. For each target group a set of unified monitoring tools was identified and is at disposal of the Dissemination team to select and implement the most appropriate tool for each specific event/activity. At the end of the project, a full monitoring report was prepared, containing information on project implementation and impact .

### E1: The Advisory Board and networking and E3: After LIFE Communication plan

The action and its sub-actions have been finalized in time for the amended due date.

At the beginning of the project the Advisory Board was set up with representativesfrom the EUFORGEN Steering Committee, experts from SE Europe, and relevant ministries. The experts from SE Europe (National Focal Points, NFPs) were chosen among EUFORGEN national coordinators and EUFGIS national focal points (an AGRI GEN RES project lasting from 2007 – 2011). Three AB meetings were organized.

The time and scope of the meetings were discussed among the CBP and ABPs, the agenda finalized before the meetings, and accepted at the meetings. The AB meetings were chaired by the PC and helped by the BL as moderators. Rapporteurs were nominated to check the minutes, and the decisions checked by the whole consortium before the end of the meeting.

Professional networking was a combined activity of actions A, B3, D2 and E1, organized within E1. It included an invitation of experts to AB meetings, presenting of LIFEGENMON at other LIFE and EU projects, IUFRO and FAO meetings, congresses and conferences, COST actions and trainings, and inviting experts from such projects and actions to the AB meetings.

Action E3 was closely linked to actions E1 and B3. The work for After LIFE communication plan started with the 3rd Advisory Board meeting during which the draft After LIFE Communication plan was set up. Throughout the project duration and the Advisory Board and Technical Board meetings the Plan has been elaborated. The bulk of work took place in late 2019 and 2020 (also during the extension period) with Zoom partner meetings. Main focus of the Plan is to present the need for forest genetic monitoring (FGM) and its feasibility (based on the Decision support system) to the national and international stakeholders and policy makers, incorporate it into long-term strategies, such as the European forest genetic resources strategy, as well as the European genetic resources strategy, the Biodiversity strategy, and the New European Forestry strategy. At the national level, the close communication with ministries and forest management planning authorities has enabled to incorporate the need to conserve forest genetic diversity and monitoring of its changes into forestry and conservation practice, guidelines, programmes and legislation. It is named to be the best instrument to support future forests and forestry in the changing climates.

The main objectives of the AFTER LIFE ACTION PLAN were:

● Promotion of genetic diversity in Forest policy and strategies at national level, regional and Pan-European levels;

● Promotion of measures to support conservation of the adaptability of forest populations to the changing climate, including implementation of forest genetic monitoring to detect any changes in genetic variation over time;

● Promotion of forest related topics, in particular the importance of genetic diversity in educational programmes at different levels, organized outdoor activities, science-nature days and summer schools.

Through:

* Intensifying research on climate change and silvicultural practices impacts on genetic diversity
* Improving production and use of quality reproductive material
* Improving transfer and traceability of forest reproductive material
* Reinforcing international cooperation
* Replicability, demonstration and transferability of the implementation of FGM
* Transfer of GD research for implementation in silvicultural practices based on the well established science-practice-policy communication system

The AFTER LIFE ACTIVITIES include:

* Conservation and promotion of genetic diversity in silvicultural practices with emphasis on production and use of forest reproductive material while considering the constraints in the national legislation and defining the measures for genetic protection of forests in the partner countries, in SEE and at the PanEuropean scale
* Strengthening and widening actions for conservation of FGR and monitoring of genetic diversity, including promotion and presentation of the Manual and Guidelines for FGM
* Strengthening communication activities regarding general public conception of forests, forestry and the importance of biodiversity at all levels, strengthening the communication channels with practice and policies (policy makers) in nature conservation and forestry at the national, regional and Pan-European scale
* Defining the needs and sources for funding of sustainable use, conservation and monitoring of forest genetic diversity, including the incorporation of FGM into a list of existing and future research and implementation projects at the national and international
* Identifying the impact indicators, as well as best practices and recommendations for conservation, use, and sustainable management of forest genetic resources in the changing environments.

### E2 Project management and monitoring of project progress

E2 action has started together with Action A3 in July 2014 with partner meeting and setting up management structure.

The action has been presented in more detail in chapter 4.2. Due to Covid measures the action along with other project activities has been prolonged to December 2020 (May 2021 for Project Manager, Financial Manager and Project Coordinator to finalize the Final Report).

The workload has been planned very efficiently, which resulted in lower expenditure of the action, as reported in Chapter 6.

## 4.2. D: Communication and Dissemination action

### D1 General Dissemination

**Action summary according to expected results**

The Home page website www.lifegenmon.si has been established and later updated to an architecture that enables simple and up-to date uploading of the material. It is linked to the project’s Portal<http://znanjezagozd.si/> for publishing that was launched at the end of July 2018 in Slovenian and English. The social media profiles are in function and very active during communication peaks. The Facebook profile had in the reporting period 655 Iikes and the Twitter profile 481 followers.

Seven Newsletters were published, the general pamphlets were printed, The short version of the Inception report and the Short version of progress report 2016 were published all project languages and in English, the Short version of the progress report 2019 and the Short version of the final report, however, were only published in e-version in English because of higher efficiency and effectiveness. The first Layman’s report was published in 2019 and was published in an electronic version. The final Layman’s report is printed in languages of the partner countries and in English.

In 18 training courses for teachers, more than 700 teachers were reached. The Handbook for Learning and Play in the Forests (developed in cooperation with LIFE+ ManFor CB. D. project ) was published in Slovenian and in English, both are available online (free download.). Workshops for children have reached more than 5.000 children. 3 children’s books were published in 2017 in all 4 project languages, later also in Bosnian. The Slovenian edition was reprinted in 2020 due to a very high demand, in 1000 copies. The AWG developed a forest pedagogic computer game in three languages for Android called “Seedhunter” and reached 1.000+ downloads in Germany only. 12 activities for families have reached 2782 in all partner countries together.

For special groups of target audiences 19 visits to the plots have been realised: 10 in Germany, 4 in Slovenia and 5 in Greece with 531 participants in total. Open days for the general public were organized in all project countries, 11 in Germany with 1407 participants, 5 in Greece with 1900 participants and 28 in Slovenia with 1487 participants. In total, open days reached more than 4000 people at several locations and events.

The project team has been successful in working with the media. In the reporting period there were 148 media pieces published about the project: 8 on EU/global level, 98 on national and 50 on regional level. There were additional 67 pieces published on the Web. There were less than expected pieces published on a regional scale, however, they were compensated on a national scale, where broader public has been reached. Out of all media pieces, 8 paid publications have been procured (4 in EU and 4 in Slovenian publications).

According to RAP, a project video was produced to present the project visually on the webpage and social media. A successful film (25 min) was produced and broadcasted on the national media (RTV in SI, with English version for EU distribution). Also, a short video (2 min) was produced based on the film. The distribution rights for a Documentary Nature Parks of Slovenia: Virgin Forest Krokar, produced by Slovenian national TV were bought. The film is subtitled in English with LIFE and LIFEGENMON logos to increase visibility of our topic and LIFE programme.

The project has co-organised several events in D1 for important groups of general stakeholders: 3 in Germany with 121 participants, 1 in Greece with 70 participants and 8 in Slovenia with 317 participants, reaching in total 450 important stakeholders. The project team has participated at 10 trade fairs and 9 popular science events.

Internal workshops for specialists doing forest inventory; Internal workshops for forest owners, users of FRM, tree dealers, nurseries, seed dealers, silviculturists and forest managers; Internal workshops for scientists from forest management, silviculture and forest genetics:

According to RAP, two workshops on the field would be organized for specialists doing forest inventory and would each last two days. Four one-day workshops were organized with less attendees for higher effectiveness. For the same reason one-day workshops with less participants were also organized for forest owners, users of FRM, tree dealers, nurseries, seed dealers, silviculturists, and forest managers. According to RAP, four workshops on the field would be organized and would each last two days. Instead, one-day workshops have been organized: 7 in Germany, 4 in Greece and 10 in Slovenia, with less than 50 participants per workshop. For scientists from forest management, silviculture and forest genetics we have also organized more workshops than predicted in the RAP. According to RAP, three one-day workshops would be organized for 20 participants. There were 11 workshops organized as they proved to be a very good way to disseminate the knowledge to the professionals.

LIFEGENMON project team was participating at a few workshops with regional forest management and heads of regional departments for silviculture and protection of forests with committees on forest reproductive material, responsible for forestry in Slovenia, discussing FGM progress.

Five open access articles were published in the Scientific magazines, in addition many pieces of professional and scientific work have been published and co-published.

The guidelines for forest genetic monitoring for seven tree species have been published, scientific illustrations have been made, each of the seven tree species was illustrated by a certain scientific illustrator.

The legislative documents were presented at the International Congress on Engineering and Life science - ICELIS 2018 in Kastamonu Turkey, in 2019, protocols for the understanding the important parts of legislation in silviculture were published.

Lifegenmon has organized, in cooperation with SASA, four scientific conferences called ‘Gozd in Les’ and participated at international Scientific conferences, at scientific, professional, legislative and governance events.

Project Video

A project video was produced to present the project visually on the webpage and social media.

A Film (25 min) was produced and broadcasted on the national media (RTV in SI, with English version for EU distribution). The topic is forest and climate change, emphasizing the importance of genetic diversity to preserve the adaptive potential of forests to the changing environment. Also, a short video (2 min) on the basis of the film was produced. Public procurement has been carried out by SFI in 2019, RTV Slovenia has been selected (19.850 EUR excluding VAT), since other providers have been significantly more expensive. We have bought distribution rights for Documentary Nature Parks of Slovenia: Virgin Forest Krokar, produced by Slovenian national TV. The film is subtitled in English with LIFE and LIFEGENMON logos to increase visibility of our topic and LIFE programme. These films contribute to reaching the audiences that do not usually follow forestry topics. Both films will be repeatedly shown on the national television RTV Slovenia.

There were three videos about the LIFEGENMON plot and two virgin forests produced by RTV Slovenia: Plot Pri Studencu, virgin forest Rajhenav, virgin forest Krokar <http://www.lifegenmon.si/lifegenmon-featured-films-and-videos/>. They were produced to substitute the real excursions before the final LIFEGENMON conference where they have been shown. The excursions have been cancelled because of the coronavirus restrictions; the online version has been well visited.

Also in Germany, the AWG decided to produce a project film for web instead of the 6 regional TV clippings and radio broadcasts, after two successful clippings of the project on National television. As AWG did the conceptual work, filming and editing in-house, the needed extra hours to cover these tasks were approved by the monitor. The most important films and videos are published on the project's website (http://www.lifegenmon.si/lifegenmon-featured-films-and-videos/) <https://vimeo.com/559932310>.

AUTH: two videos have been produced: Forest genetic monitoring field work and Forest genetic monitoring laboratory work also available at <http://www.lifegenmon.si/lifegenmon-featured-films-and-videos/>.

### D2 Target Dissemination

D.2.1 Stakeholders

Within this part of dissemination, target dissemination, the stakeholders are either policy makers or connected to/working with forest, nature or climate/environmental change. The partners in the project have defined the most important groups and have identified them in each participatory country. Groups of stakeholders on local/regional/national and European level were already defined at the kick-off meeting.

Workshops

Four one-day workshops were organized for specialists doing forest inventory, two in Slovenia, one in Germany and one in Greece. Less participants in a group were allowed to have time for a discussion and answers, that were important to provide views on integration of FGM into forest management and inventory.

We have organized one-day workshops, seven in Germany, four in Greece and ten in Slovenia, with less than 50 participants per workshop.

For scientists from forest management, silviculture and forest we had 11 workshops and have reached 617 scientists. Three workshops were in Slovenia, six in Greece and two in Italy.

LIFEGENMON project team was participating at a few workshops with regional forest management and heads of regional departments for silviculture and protection of forests with committees on forest reproductive material, responsible for forestry in Slovenia, discussing FGM.

D2.5 Compilation of scientific publications in scientific papers

Five open access articles were published in the Scientific magazines:

* “FOREST GENETIC MONITORING: AN OVERVIEW OF CONCEPTS AND DEFINITIONS”, authored by Barbara Fussi, Marjana Westergren, Filippos Aravanopoulos, Roland Baier, Darius Kavaliauskas, Domen Finzgar, Paraskevi Alizoti, Gregor Božič, Evangelia Avramidou, Monika Konnert, Hojka Kraigher.
* “THE INTERPLAY BETWEEN FOREST MANAGEMENT PRACTICES, GENETIC MONITORING AND OTHER LONG TERM-MONITORING SYSTEMS”, authors: Darius Kavaliauskas , Barbara Fussi, Marjana Westergren, Filippos Aravanopoulos, Domen Finžgar, Roland Baier, Paraskevi Alizoti, Gregor Božič, Evangelia Avramidou, Monika Konnert, Hojka Kraigher.
* Brus R., Božič G., Kraigher H., Jarni K. (2019) Register of Wild Cherry (Prunus avium L.) Plus Trees in Slovenia. In: Šijačić-Nikolić M., Milovanović J., Nonić M. (eds) Forests of Southeast Europe Under a Changing Climate. Advances in Global Change Research, vol 65. Springer, Cham. <https://doi.org/10.1007/978-3-319-95267-3_23>
* Kraigher H., Bajc M., Božič G., Brus R., Jarni K., Westergren M. (2019) Forests, Forestry and the Slovenian Forest Genetic Resources Programme. In: Šijačić-Nikolić M., Milovanović J., Nonić M. (eds) Forests of Southeast Europe Under a Changing Climate. Advances in Global Change Research, vol 65. Springer, Cham. <https://doi.org/10.1007/978-3-319-95267-3_3>
* Božič G., Kraigher H. (2019) International European Beech Provenance Trial Kamenski hrib/Straža in Slovenia. In: Šijačić-Nikolić M., Milovanović J., Nonić M. (eds) Forests of Southeast Europe Under a Changing Climate. Advances in Global Change Research, vol 65. Springer, Cham. https://doi.org/10.1007/978-3-319-95267-3\_24

D2.6 Project report with technical information

The Inception report with technical information has been e-published. Printing has been abolished due to economic and environmental reasons. We have included technical information in the Short version of the project report to lower the costs by issuing 1 publication including all the information.

D2.7 Publication of the guidelines for forest genetic monitoring for seven tree species

According to RAP the guidelines are renamed to "Publication of the guidelines for forest genetic monitoring for seven tree species", see also action B2. The scientific illustrations were made for the Manual and the Guidelines, each of the seven tree species was illustrated by a certain scientific illustrator.

D2.8 Leaflets for promotion of legislative documents processed within the project at EU level

In 2018 we presented legislative documents at the International Congress on Engineering and Life science - ICELIS 2018 in Kastamonu Turkey. In 2020, we published a leaflet for promotion of The Manual and Guidelines for forest genetic monitoring. It includes links to the e-versions of the Manual in four languages, short description of the project and a reasoning why genetic monitoring and the main content. It will be used during AfterLIFE activities.

In addition, we have issued two leaflets in 2019 that help foresters understand the important parts of legislation in silviculture in Slovenia: Protocol for the production of forest reproductive material and the Seedling management protocol. We have distributed them to foresters, professionals. These two protocols are, however, only available in Slovenian.

D2.9 Scientific conferences

According to RAP, SFI should have organized two Scientific conferences. SFI has organized, in cooperation with SASA scientific conferences called ‘Gozd in Les’, in translation ‘Forest and Wood’. It was held every year, from 2015 to 2019. In 2015, the Scientific meeting was held at SFI, in 2017 and 2018 and 2019 at the SASA. In 2016 it was co-organized by SFI in Cankarjev dom, Congress hall in Ljubljana. It reached more participants every year, from 30 in 2016 to 74 in 2019. In 2019, the scientific conference Forest and Wood was recorded to be available for a larger audience. <https://www.youtube.com/watch?v=dvQYY-Q9jNE&list=PLhQ92XwY2ZPHbkN2KC50fYxhGxwaBgi_a>.

LIFEGENMON participated at other Scientific conferences. In 2017, the LIFEGENMON Session “Forest policy and biodiversity strategy: The relevance of forest genetic resources” at IUFRO 125th Anniversary Congress in Freiburg, Germany (approved by NEEMO) reached a bigger international audience, with 63 participants. The second IUFRO congress that LIFEGENMON participated at, was the conference XV IUFRO World Congress 2019: "Forest Research and Cooperation for Sustainable Development", in Curitiba, Brazil (29 September - 5 October 2019). Additional scientific conferences were INORMS 2018 Conference in UK and the COP in Katowice, where LIFEGENMON had presentations.

Finally, LIFEGENMON organized the final conference of the project from September 21st till September 25th in 2021. The conference was due to SARS-CoV-2 organized mainly as an on-line event. However, the speakers that could attend in person, gathered in the Biotechnical faculty in Ljubljana, the live stream was broadcasted. It was a part of the EU Green Week events. In five days, over 100 participants attended 82 expert papers, 3 virtual excursions and a final round table discussion on the future of forests by representatives of Slovenian and European institutions in the field of forestry, woodworking, education and forest owners.

D2.10 Participation at scientific, professional, legislative and governance events

In our effort to communicate the project, its importance, and its outcomes, we have reached out to important policy makers who have the ability to legislate, make Forest Genetic Monitoring applicable and improve future forest management.

We have also participated at scientific, professional, legislative and governance events to present the aims of the project and to take part in the decision-making process. Therefore, LIFEGENMON was presented at several other LIFE and EU projects, EC, IUFRO and FAO meetings, congresses and conferences, COST actions and training, combined with activity of actions A, B3, D1 and E1. The most important events were DG SANTE WG on FRM in April 2017 in Arcachon, France; EUFORGEN WG on FRM in March 2017 in Warszaw, Poland; EUFORGEN SC meeting in Amsterdam, Netherlands in May / June 2017; AForGen meeting in June 2017 in Italy, FOREST GENETICS Congress in June 2017 in Canada; LIFEGENMON & GENTREE in Thessaloniki, Greece in October 2017, as well as at national and international meetings with ministries, responsible for forestry or the environment. IUFRO Congress in Freiburg in 2017, Germany and IUFROWorld Congress in 2017 and in 2019 are already reported in D2.9. There were 39 participation events with more than 2500 attendees.

The most important professional and scientific work published

The *Silva Slovenica* publishing centre has co-published in the framework of the LIFEGENMON project four monographs:

* Ballian, Bozic: Biokemijska varijabilnost smreke (Picea abies Karst) u Bosni i Hercegovini
* Balllian, Halilovic: Varijabilnost obicne jele (Abies alba Mill) u Bosni i Hercegovini
* Ballian, Memisevic Hodzic: Varijabilnost hrasta lužnjaka (Quercus robur L.) u Bosni i Hercegovini
* Ballian: Varijabilnost crne topole (Populus nigra L.) i njeno očuvanje u Bosni i Hercegovini

It has also published 4 proceedings of Scientific Meetings Forest and Wood in cooperation with SASA:

* 2016 - http://dx.doi.org/10.20315/SilvaSlovenica.0001
* 2017 - https://doi.org/10.20315/SFS.157
* 2018 - https://doi.org/10.20315/SFS.159
* 2019 - <https://doi.org/10.20315/SFS.163>

And the Seed practicum ‘Semenarski Praktikum’ , Kraigher, Hojka ISBN 978-961-6993-49-4  
COBISS.SI-ID 301851136

D.2.12 Workshops and summer schools for students

For students five workshops were organized in Germany with 245 participants, three workshops in Greece with 111 participants and five workshops and 10 presentations in Slovenia were organised. In addition, three summer schools on scientific writing and forest genetic monitoring knowledge transfer into practice were organized in Slovenia. ).

D2.13 Workshops for stakeholders across the transect area

In years 2019-2020 a series of workshops were organized for promotion of forest genetic monitoring and presentation of the decision support system, the Manual and guidelines in the transect countries, in Sarajevo, Jastrebarsko (Croatia), Novi Sad (Serbia), Banja Luka (Bosnia and Hercegovina), Skopje (

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| --- | --- | --- |
| Date | Place | Title |
| 24.6.2019 | Sarajevo (Bosnia and Herzegovina) | Measures for conservation of forest and forest genetic resources |
| 2.12.2019 | Jastrebarsko (Croatia) | Conservation of forest genetic resources - policy and practice |
| 5.12.2019 | Novi Sad (Serbia) | Measures for conservation of forest and forest genetic resources |
| 6.12.2019 | Banja Luka (Bosnia and Herzegovina) | Measures for conservation of forest and forest genetic resources |
| 10.3.2020 | Skopje (North Macedonia) | Measures for conservation of forest and forest genetic resources |

D2.14 Common Workshops with complementary projects and programs

Our project members connected with other projects and programs on several occasions, presented our project aims at LIFE program events, at IUFRO and FAO meetings, at EC events, COST Actions and trainings. In addition, LIFEGENMON project team was/is in constant cooperation with projects: LIFE EMONFUR, LIFE MANFOR C.BD, LIFE DINALPBEAR, LIFE ClimatePath2050, LIFE Lynx, LIFE ARTEMIS, LIFE Grin, Projects GenTree , SeeMLA and others.

A LIFE networking visit has been organized by the SFI for delegates from LIFE HESOFF project in May 2016. In September 2016 LIFEGENMON was presented at LIFE networking conference “Okrepljeni do evropskih sredstev – LIFE” together with a press conference at Slovenian Forestry Institute, Slovenia. In February 2017 visit of delegates from the 16+1 sub-regional cooperation format China and 16 central and eastern European countries (CEECs) by the representatives of the Ministry of Agriculture, Forestry and Food of the Republic of Slovenia (http://www.gozdis.si/novice/institut-gostil-delegacijo-iz-sestnajstih-evropskih-drzav-in-kitajske-2017-02-19/), while in October 2017 LIFEGENMON was presented at the meeting of 16+1 in Beijing. In March 2017 a visit of delegates from INFORMED 3rd plenary meeting took place. In addition, the LIFEGENMON team presented their experience at LIFE International networking conference "Environment needs LIFE for the next 25 years" in Ljubljana and LIFE info day in Portorož, Slovenija in 2017. In 2018, LIFEGENMON presented at the LIFE Platform Meeting on CCA in Agriculture and Forestry, Madrid at the COST Action FP1403 Biolink, Granada and at the OECD EC event in Slovenia. In 2019, the most visible event was the AForGen annual meeting, IUFRO 2.04.11 and meeting of Silver Fir Genome Project Group in Mt. Ventoux in France.

## 4.3. Evaluation of Project Implementation

Monitoring in 2015-2016 was focused primarily on processes and communication and less on the outputs and deliverables. This was due to the fact that the implementation of the project was still in its early phases and that most of the activities monitored were part of preparatory actions, dissemination and project management while the activities under Action B (Implementation) have only begun. In 2017 we increased the monitoring activities in Action B (implementation) with a special focus on monitoring impact. Different tools have been prepared to effectively carry out this kind of assessment (such as before/after surveys to measure the change of attitudes).

Monitoring was intense in the phase of preparation of the Refined Action Plan since some of the changes derived from the monitoring and evaluation of the current situation. Changes proposed in it reflect the identified possibilities for bigger effectiveness and impact and/or shortcomings of the current state.

In the middle of the project (in 2016) the monitoring activities have been extended to setting the qualitative and quantitative outcome indicators at project level for LIFE programme. This was quite a challenging task, since the indicators were pre-set and, in most cases, did not directly correspond with the project goals. This issue also brought additional burden for Action Leaders and partner organizations as they had to organize additional activities and collect extra data that were not foreseen in the project application.

in the later years (2018 - 2020) the constant progress in technology and scientific research become major topics for discussions among team members as they had a direct impact on the final project outputs and results (mainly policy recommendations, guidelines and protocols for genetic monitoring) as decisions had to be made and agreed among all project partners.

In 2020 the biggest challenge was Covid-19 pandemic that had a huge impact on the closure of the project and dissemination of results. The final conference had to be postponed to autumn and carried out as live/zoom/on-line event to enable participation from different countries and stakeholders. Also, last Advisory and Technical Board meetings had to be conducted on-line.

1. “FOREST GENETIC MONITORING: AN OVERVIEW OF CONCEPTS AND DEFINITIONS”, authored by Barbara Fussi, Marjana Westergren, Filippos Aravanopoulos, Roland Baier, Darius Kavaliauskas, Domen Finzgar, Paraskevi Alizoti, Gregor Božič, Evangelia Avramidou, Monika Konnert, Hojka Kraigher [↑](#footnote-ref-2)
2. KAVALIAUSKAS, Darius, FINŽGAR, Domen, BOŽIČ, Gregor, PISEK, Rok, ŠTURM, Tomaž, VESELIČ, Živan, WESTERGREN, Marjana, KRAIGHER, Hojka, et al.*. Selection and establishment of forest genetic monitoring plots : guidelines draft*. Ljubljana; Teisendorf; Thessaloniki: Gozdarski inštitut Slovenije, 2015. [↑](#footnote-ref-3)