GENETIC RESOURCES
THE KEY TO ADAPTATION OF FORESTS TO GLOBAL CHANGE

SCIENCE-TO-POLICY **EVENT**

BRUSSELS, 13 DECEMBER 2019 - RADISSON RED HOTEL, RUE D'IDALIE 35

A joint policy event was organized on 13 December 2019 in Brussels by representatives of four EU projects - GenTree, SUSTREE, SPONFOREST and LIFEGENMON – and the EUFORGEN international programme, with the objective to present and discuss the relevance and implications for policy and practice of research work recently completed. The organizers were:

- Bruno Fady, INRA (France) coordinator of the GenTree project (H2020)
- Barbara Vinceti (Alliance Bioversity-CIAT), partner in the GenTree project (H2020)
- Arndt Hampe, INRA (France), coordinator of the SPONFOREST project (BiodivERsA)
- Silvio Schüler, BFW (Austria), coordinator of the SUSTREE project (Interreg)
- Hojka Kraigher, SFI (Slovenia), coordinator of the LIFEGENMON project (LIFE)
- Michele Bozzano, EFI (International), coordinator of the EUFORGEN programme

The event was opened by the moderator, Jeremy Cherfas (independent consultant), who introduced the various initiatives that contributed to organizing the event. Then, he gave the word to Barbara Vinceti (Alliance Bioversity-CIAT) who provided a general introduction and an illustration of some general concepts regarding forest genetic resources conservation and management, and gave a short presentation on key findings from the EU-funded research project GenTree on behalf of the coordinator, Bruno Fady (INRA) as he could not be present. The BiodivERsA project SPONFOREST was then illustrated by Santiago Gonzalez-Martinez (INRA, France) on behalf of the coordinator, Arndt Hampe (INRA, France), who also could not participate. He was followed by Silvio Schueler (BFW, Austria) who presented the Interreg project SUSTREE and by Hojka Kraigher (SFI, Slovenia), who illustrated key elements of the LIFE project LIFEGENMON.

(see an overall power point presentation attached to this report; pages 9-15).

The meeting was attended by 28 participants, including organizers.

(see the full list of participants at the end of the report)

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Short introduction to key concepts

What are forest genetic resources (FGR) and why do they matter?

- Within species diversity of trees and other woody plants
- Crucial for adaptation and adaptability of our ecosystems, landscapes and production systems

How do trees respond to environmental changes?

- They can adapt to new conditions in current locations
- They can migrate to track suitable conditions
- If adaptation and migration are not possible, the consequence could be local extinction

How is FGR conservation carried out?

- In situ conservation refers to the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings.
- Ex situ conservation refers to the conservation of components of biodiversity outside their natural habitats.

Management of FGR fosters adaptation to / mitigation of climate change

- Silvicultural choices
- Management of forest reproductive material (FRM)
- Choices are largely influenced by biological aspects but also by the socio-economic context
- Often multiple objectives/ecosystem services are targeted at the same time

Silvicultural interventions can (1) increase the chance of emergence of 'innovative' genetic combinations, (2) facilitate the spread of the best adapted genotypes and (3) preserve genetic diversity for long-term response to selection; affecting demography (Lefevre et al. 2013)

Examples of critical silvicultural choices that affects forest genetic resources: management of tree density of target species, management of tree species composition, choice of regeneration approach, length of rotation

What is assisted migration?

Assisted migration implies the movement of planting material outside the current range of a tree species, while 'assisted gene flow' implies the managed translocation of individuals, seed or pollen within the current species range to facilitate rapid adaptation to climate change (Aitken and Whitlock 2013).

What is being done on forest genetic resources in Europe?

- EUFORGEN - European forest genetic resources programme (established in 1994)
- Pan-European Strategy for genetic conservation of forests trees
- EUFGIS - European Information System on Forest Genetic Resources
- FOREMATIS - Forest Reproductive Material Information System

Relevant discussion platforms and policy initiatives

- Global Plan of Action for the Conservation, Sustainable Use and Development of Forest Genetic Resources (GPA-FGR), adopted by the FAO Conference in 2013
- FOREST EUROPE

- Convention on Biological Diversity (CBD)
- EC Directive 99/105 on Forest Reproductive Material
- Many policies have an indirect impact on the conservation and use of FGR (often not spelled out explicitly, reference to 'biological diversity')

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Policy implications of the findings from each initiative presented

GenTree

- Natural forests host a large genetic diversity – it needs to be protected dynamically
- Genetic conservation needs to be carried out range-wide, i.e. often beyond the European Union borders
- Including evolutionary thinking into forest management can reduce vulnerability of forests

SPONFOREST

- By 2100, spontaneously established forests will represent a significant portion of the overall forest cover in Europe
- Natural reforestation can be a cost-effective tool to create forest landscapes with diverse genetic material and enhance related ecosystem services
- This will require addressing associated risks and issues of social perception, as well as fully considering the opportunities brought about by new forests

SUSTREE

- Forest adaptation to climate change requires better legislation and cooperation among countries because present European and especially national legislations on genetic resources hinder adaptation management
- Present Regions of Provenance (seed zones) do NOT consider climate and climate change
- Seed transfer models based on Europe-wide experimental trials can be used as a basis for assisted migration.
- Assisted migration and assisted gene flow will enhance the resilience and reduce the vulnerability of European forests, but they need to be implemented at the European scale to adapt European forests to climate change.
- The implementation of assisted migration requires stronger transnational coordination in seed management and tree breeding.

LIFEGENMON

- Genetic monitoring is the only tool to follow the adaptation of trees to changing conditions in different parts of the distribution range, e.g. rear or leading edge, whether established through natural regeneration, assisted geneflow, assisted migration or planting in plantations. It provides invaluable information for sustainable forest management.
- Genetic monitoring can be applied in practice on basic, standard or advanced levels. The selected level depends on the monitored population, the processes and the level of detail one wants to follow and achieve as well as funds available.
- Sustainable use of forest genetic resources starts with awareness on their importance. Targeted communication is essential to raise this awareness, and to provide professional
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background documents for preparation of future legislation and strategies, aimed at conservation of forest genetic resources for sustainable management of future forests.

EUFORGEN – recommendations with policy relevance

Conserve forest genetic resources at all levels - key for the adaptation to climate change

Climate change is a severe threat to forests. Genetic diversity ensures that forest trees can survive, adapt and/or evolve under changing environmental conditions. Future management options to adapt forests to climate change heavily rely on the availability of appropriate forest genetic resources. All European countries should collaborate to implement the pan-European strategy for genetic conservation of forest trees which aims to conserve the evolutionary potential of European forest tree species in a network of dynamic genetic conservation units. Moreover, the conservation of forest genetic resources needs to be improved at all levels of sustainable forest management in order to secure future adaptation of forest to climate change and the continued delivery of its services.

Facilitate the appropriate choices of forest reproductive material

The use of forest reproductive material that is genetically fitted for a specific site requires a sound knowledge about its identity, adaptive traits and adaptation potential. The identification and characterization of forest reproductive material should be improved, and science-based tools should be developed and made available to support end-users and the regulating framework in the decision making. Key information should include inter alia provenance recommendations, indicators for genetic diversity and, when available, results of genetic tests.

Monitor adaptation and evolutionary potential of transferred forest reproductive material

Since forest reproductive material has been moved across Europe for a long time and in the future assisted migration is likely to become one of the adaptive measures for climate change, it is crucial to monitor adaptation and evolutionary potential of the material moved under different environmental conditions. An online information system for geo-referenced records of the origin, movement and use of forest reproductive material should be created to record the production, marketing and end use of the forest reproductive material and, where available, performance data too.

Wrap up of main messages

- Forest management is key for the conservation of forest genetic resources and silvicultural measures can foster evolutionary adaptation in forests.
- Genetic diversity is a nature-based solution for the resilience and adaptation of forests to climate change; it can be harnessed by management.
- Newly managed forests, despite their diversity, also need adequate management measures to ensure they deliver the desired ecosystem services.
- In some contexts, natural regeneration can be insufficient to guarantee adaptation and movement of forest reproductive material may be necessary, following science-based guidelines. Where needed, the use of artificial regeneration should not be constrained by the normative framework.

- The tools that have been developed to support decision making, based on genetic monitoring, assist conservation of forest genetic resources and inform forest management. Resources should be made available to enable their further testing and piloting in different contexts, in collaboration with local stakeholders, to promote their implementation.
- Regulating frameworks need to promote coordination at the policy level among European countries (and neighbours) regarding conservation of forest genetic resources and the use of forest reproductive material. Resources should be made available at the European level to ensure that that transnational efforts guide the implementation of conservation and sustainable use of FGR at country level, as part of a strategy to adapt to climate change.

Clarifications and points for discussion

- **What is meant by 'evolutionary thinking' in forest management?** A type of silviculture that combines other objectives with productivity, such as adaptation to climate change. It is also a type of silviculture in which mortality is considered a driving element of adaptation, not a catastrophic event. Some trees with good characteristics are retained on purpose so they can regenerate and can contribute to a new generation of trees with desirable traits beyond productivity (e.g. disease resistance, drought tolerance, etc.). Objectives of the management can be, for example, the maximization of fructification and reproduction of a fair number of tree individuals, to offer a wide basis for selection to operate.
- **Spontaneously expanded forests accumulate biodiversity over time. What other diversity was assessed beyond genetic diversity of trees?** Increasing diversity was observed for species richness of woody plants, for different guilds of associated insects (seed predators, herbivores, etc.), and for birds. Detailed analyses of tree functional diversity (growth form, wood density, water use efficiency, etc.) were also conducted, providing a direct link between biodiversity and ecosystem functioning.

- **Is there an expectation that spontaneous expansion of forests will continue further into the future? If yes, at the expense of what other land uses?** The expansion observed will definitely increase further. On one hand, the rural exodus and the abandonment of marginal farmlands (both arable and pastures) continue to be widespread phenomena in European countries, leaving extensive spaces available for the spontaneous expansion of second-growth forests. On the other hand, spontaneous reforestation is increasingly used as a cost-efficient tool for passive restoration in fragmented landscapes, including peri-urban areas. Both aspects are currently spurring an intense debate around the topic of 'rewilding'. Unfortunately, the extent of spontaneous forest regrowth can at present hardly be quantified because studies make no distinction between planted and non-planted new forests.
- **Is there an influence of previous land uses on the characteristics and trajectory of spontaneously expanded forests?** New forests growing on former farmlands tend to outperform long-established forests in terms of individual tree growth, water use efficiency and nitrogen cycling. This is probably a consequence of greater soil nutrient availability as a legacy of the previous land use.
- **How can we define detectable thresholds for survival of tree species in the face of expected future climate conditions and what is the current collaboration with climate experts?** There is a lot of uncertainty in climate predictions. In discussing with climate experts, it is clear that change is expected but different climate models do not always align in their predictions, so there are big uncertainties. The only clear aspects are that extreme conditions will be experienced in the northern and southern parts of Europe. So, the best strategy is to be prepared for whatever comes. There is a need to start experiments to deal with uncertainty. The tool that has been developed in SUSTREE, to guide the movement of forest reproductive material to be planted, is based on future probabilities of finding suitable climatic conditions for a certain tree species in a specific place, so, in a way, this tool already accounts for species-specific critical thresholds in suitable climate conditions. A practical suggestion regarding forest reproductive material could be to better characterize the genetic diversity of the seed stand of origin of the planting material and make this information part of a standard set of data provided and stored, for example, in the information system maintained by the European Commission (FOREMATIS). This would give a sense of the potential adaptability of the planting material.
- **Is there need for more research to refine transfer guidelines for upscaling movement of forest reproductive material?** The primary need is to pilot the approaches already elaborated, implementing and testing the tools already developed, working closely with seed producers and nurseries.
- **Today what guides the transfer of forest reproductive material are provenances; shouldn't we possibly implement a different system and more harmonized approaches across countries?** We should base transfer guidelines on a combination of provenance information and information coming from the local experience of climate change. Transfer guidelines are based on expected performance of provenances under climate change scenarios, and this should be combined with data on actual performance of what has been planted. In addition to developing models, it is important to keep records and document the performance of the forest reproductive material used. However, we do not have a systematic data collection system on the performance of forest reproductive material and a platform where to store the data collected. In a similar way, databases should be developed with data from genetic monitoring.

- **There is a focus on assisted migration as opposed to the use of local material in some contexts, but this may encounter opposition of those involved in conservation, so we would need some experiments that enable to compare these options.** There is a general perception that local material is the best performing, but if we think that in Scandinavia 15,000 years ago there were no trees, it is clear that the establishment of these forests must have taken place with seed coming from outside that region, through transfer followed by admixture on which selection has operated. A strong selection pressure ensures that locally useful traits are maintained. However, we need to consider that tree diversity in Europe is lower than in other forested regions of the planet because forests in Europe have been confined by glaciations, so they are potentially vulnerable to climate change. In addition, migration is constrained in fragmented landscapes and suitable conditions may be too far away for trees to reach them. Thus, assisted migration should be considered as a further option in addition to the use of local planting material, not as an opposed strategy.
- **We have old provenance trials that continue to generate data on tree performance, but when these trials were established, they were not conceived in a way to respond to questions related to climate change**. We would need a commitment to set up new trials to test the influence of climate change. It should be also considered the possibility of setting up new provenance trials in regions where the tree species of interest where not living in the past. Common gardens are still very informative experiments although resources to set them up are difficult to find and, in addition, we would need to overcome the common problems of lack of continuity in the evaluation of these trials in the long term, when the funding ends. A complementary, very promising approach is to make **use nature as an experimental setting, combining forest inventory data and genomic tools**. There is lots of undocumented diversity in European forests; genomic tools are relatively cheap, and we should study heritability of adaptive traits to assess the evolutionary potential of a stand. Now we have available new tools to better characterize the environment and understand dynamics at landscape level. Breeders in Sweden and New Zealand for example use remote sensing to match forest reproductive material and landscape characteristics. The belief is that it is possible to increase productivity and carbon storage simply refining this fine scale matching of planting material and landscape characteristics. Another existing problem is when seed sources are not identified at stand level but rather at the level of provenance region (*this happens when the category 'source identified' is applied versus the category 'selected', based on the Directive 1999/105 on forest reproductive materia*l), so the performance of individual populations cannot be tracked and there could be large differences among populations within the same provenance region.
- Tree planting needs to serve many purposes related to bioeconomy, climate change adaptation and mitigation, etc. At the same time, humanity must move towards a world free of plastic. In order to do so, we may need to look at using new tree species to achieve some of these macro objectives and the industrial sector should try and consider expanding attention to new species. **The forest industry sector should adapt to the new scenarios posed by climate change, but today adaptation is more difficult because small niche industries that could test new species and adapt quickly no longer exist, but rather large enterprise, so this poses a structural limitation to change.**
- **The solutions that are being envisaged for climate change at global level are relying on forests, but tree planting is driven by market forces that follow different dynamics**, and the best seed sources that would guarantee a good performance of newly planted individuals are difficult to access. The planting material currently produced in Europe will not be enough to meet the

demand to plant trees on large areas and, in some years, seeds crops for some tree species are missing. Therefore, if a solution to climate change is tree planting, this should not be left only in the hands of the market, but more significant efforts should be promoted to make sure that use of suboptimal tree planting material is avoided to the extent possible.

- The Green Deal is a great opportunity for scientists to put forward scientific evidence that would assist in reaching the multiple goals of forestry that are demanded by the society today. It should be combined with a call to **develop an adaptation strategy at regional level**, largely based on preserving diversity in our forests, as this is a crucial to support adaptation, but also relying on interventions such as artificial regeneration, assisted geneflow and assisted migration, in circumstances when natural regeneration is not sufficient. The **Green Deal implies big changes and it needs to be combined with adequate investments, otherwise nothing will change**.
- **Coordination across countries will be crucial**; a dialogue with forest owners and nurseries should be opened, to discuss with them in terms of financial plans. Information should be made available to practitioners and forest owners, so they become aware of the consequences of using different types of forest reproductive material. **A future proactive strategy may to promote use of mixed seed from different sources and** a balance will need to be stricken between production forestry and conservation.
- In Denmark, nurseries used to take the role to inform customers on what to choose for planting, so they could also control better the production of seedlings and meet the demand for tree planting material , but **now, increasingly, in the nursery sector, external experts are involved in providing advice on what to plant**, so we see positive evolutions towards adaptation. **However, in some countries though, the market is still focused on just few provenances of few species**.

Michele Bozzano (EUFORGEN/EFI) gave some final remarks. In particular, he underlined the long-term commitment of the EUFORGEN programme in taking stock of the key findings emerging from different ongoing European projects, and in bringing scientific evidence closer to the stakeholders who are in need.

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SCIENCE-TO-POLICY **EVENT**

1

Outline

General concepts
GENTREE
SPONFOREST
SUSTREE
LIFEGENMON
EUFORGEN
Wrap up of the main messages

2

What are forest genetic resources (FGR) and why do they matter

Within-species diversity of trees and other woody plants

Crucial to enable adaptation of our ecosystems, landscapes and production systems

3

How do trees respond to environmental changes?

- They can **adapt** to new conditions in current locations
- They can **migrate** to spatially follow suitable conditions

If adaptation and migration are not possible, the consequence could be extinction

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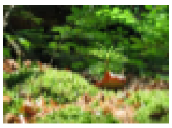
Management of FGR fosters adaptation to / mitigation of climate change

- **Silvicultural** choices
- Management of **forest reproductive material** (FRM)
- Choices are largely influenced by biological aspects but also by the **socio-economic** context
- Often **multiple objectives/ecosystem services** are targeted at the same time



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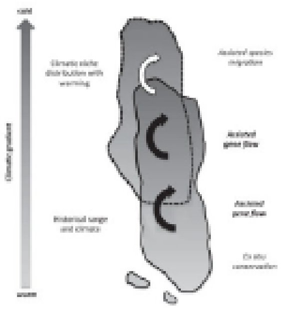
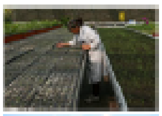
What is assisted migration?



Aitken & Bemmels (2016)



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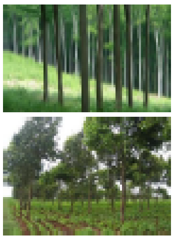
How FGR conservation is carried out

In situ conservation is the protection and maintenance of species populations in the ecosystem where they occur

Ex situ conservation is the protection and maintenance of genetic resources outside their original environment



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What is being done on forest genetic resources in Europe?

- **EUFORGEN** - European forest genetic resources programme (established in 1994)
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Relevant discussion platforms and policy initiatives

- **Global Plan of Action** for the Conservation, Sustainable Use and Development of Forest Genetic Resources (GPA-FGR), adopted by the FAO Conference in 2013
- **FOREST EUROPE**
- **Convention on Biological Diversity** (CBD)
- **EC Directive 99/105** on Forest Reproductive Material
- Many policies have an indirect impact on the conservation and use of FGR (often not spelled out explicitly, reference to 'biological diversity')

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GENTREE

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Main overarching questions

- What is the scale of genetic adaptation?
- How can management of forest genetic resources make forests more resilient?

- 12 tree species, 190 sites, 3500 trees in 12 countries across Europe
- New knowledge on ecological, phenotypic and genotypic diversity across environmental gradients in Europe
- Simulations of forest management practice on forest vulnerability

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Genetic diversity is large and structured at multiple scales

Abies alba, *Betula pendula*, *Fagus sylvatica*, *Picea abies*, *Pinus cembra*, *Pinus halepensis*, *Pinus nigra*, *Pinus pinaster*, *Pinus sylvestris*, *Populus nigra*, *Quercus petraea*, *Taxus baccata*

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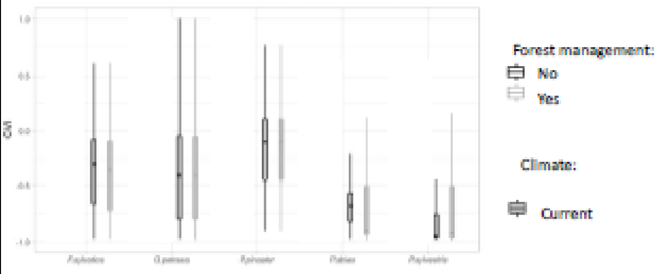
GENTREE

Silviculture can significantly decrease vulnerability



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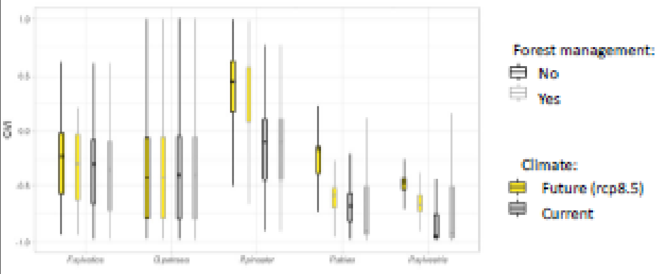
GENTREE

Silviculture can significantly decrease vulnerability



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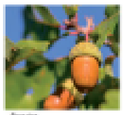
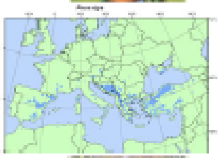
GENTREE

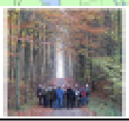
Key policy implications of the findings



- Natural forests host a large genetic diversity – it needs to be protected dynamically



- Genetic conservation needs to be carried out range-wide, *i.e.* often beyond the European Union borders
- Including evolutionary thinking into forest management can reduce vulnerability of forests



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SPON forest

biodiversa

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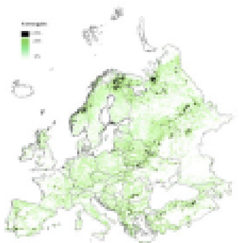
Forest expansion in Europe

Europe is the only region of the world with a positive net change in forest area during the last 25 years.

In this period forest area in Europe has increased by 17.5 million hectares (almost half of the area of Italy)

Forest Europe



Forest cover net gain 1990-2015

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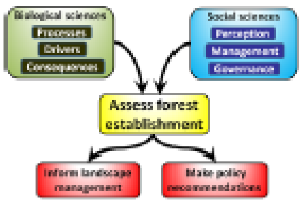
Main overarching questions

- How do new forests establish?
- How do they function and which ecosystem services do they deliver?
- How are they perceived and managed by local societies and political governance systems?



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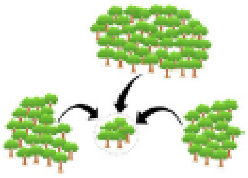
Main results

- New forests can efficiently accumulate biodiversity, including forest tree genetic diversity, over time
- Natural forest establishment in non-forested land involves extensive genetic recombination that can catalyse adaptation to climate change, as multiple seed sources are combined in unique genotypes



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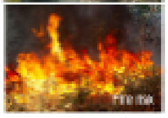
Main results

- New forests provide a broad range of ecosystem services, but can also bring new threats depending on the greater socio-economic and ecological context
- In some cases, unmanaged forest expansion is negatively perceived by local stakeholders



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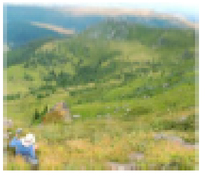
Key policy implications

- By 2100, spontaneously established forests will represent a significant portion of the overall forest cover in Europe
- Natural reforestation can be a cost-effective tool to create forest landscapes with diverse genetic material and enhance related ecosystem services
- This will require addressing associated risks and issues of social perception, as well as fully considering the opportunities brought about by new forests



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Interreg
CENTRAL EUROPE
SUSTREE
European Union
European Regional Development Fund

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Main overarching issues

- Climate change reached European forests: bark beetles, drought, storm, ice
- Huge reforestation needs with trees fit for climate change
- Forest crisis extends beyond country borders

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SUSTREE: Seeds without borders sustain forest diversity

Questions addressed:

- Are policies for reforestation and seed management fit for climate change ?
- Is assisted migration a solution to adapt forests and tree populations to climate change?

8 project partners
6 Central European countries
1.8 Mio € budget
3 years (08/2016 – 08/2019)
2 pilot actions

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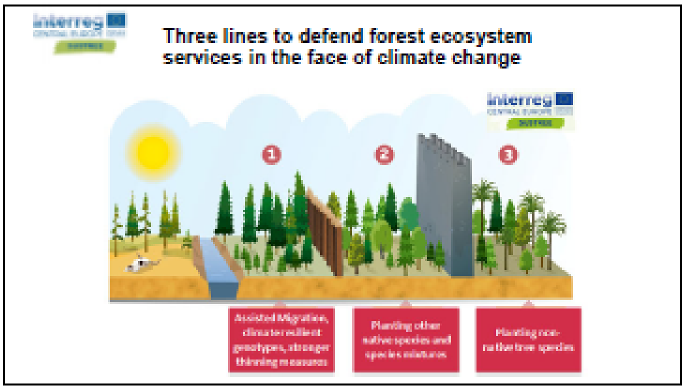

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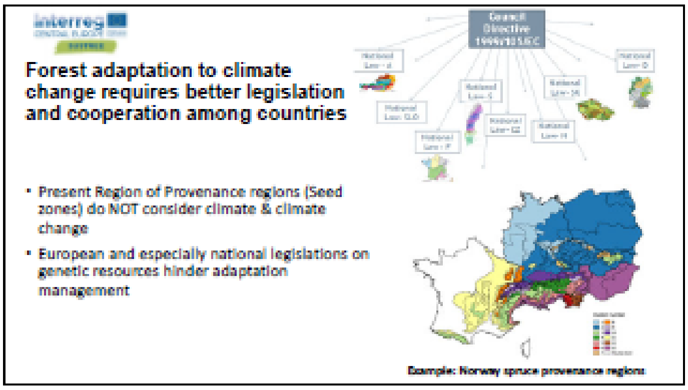

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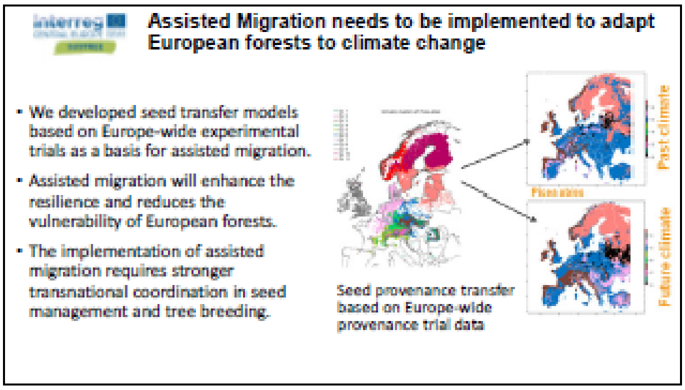

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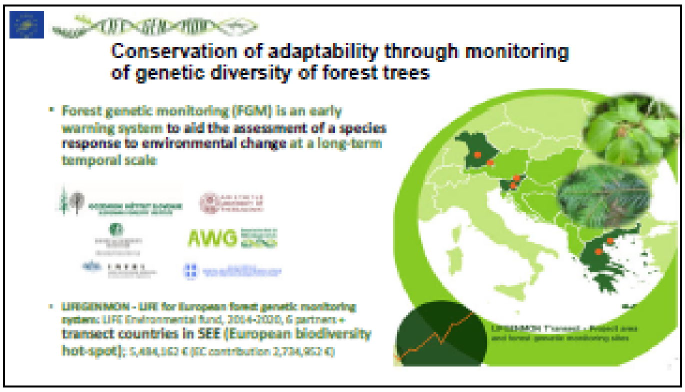

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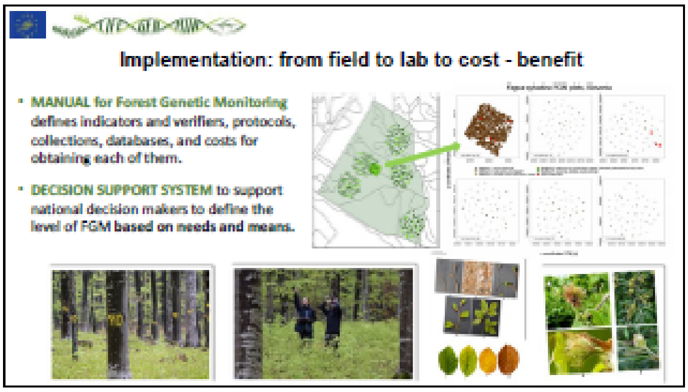

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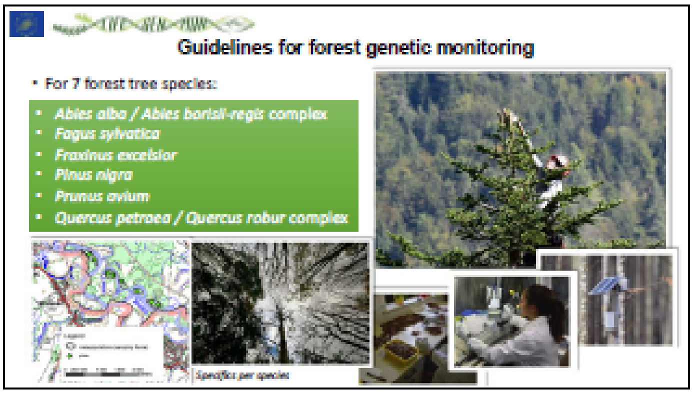

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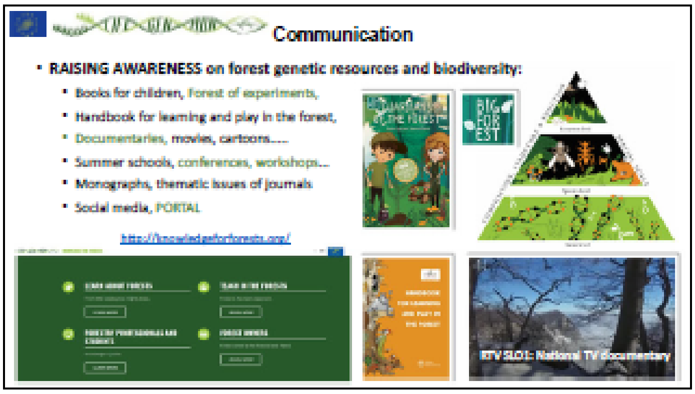

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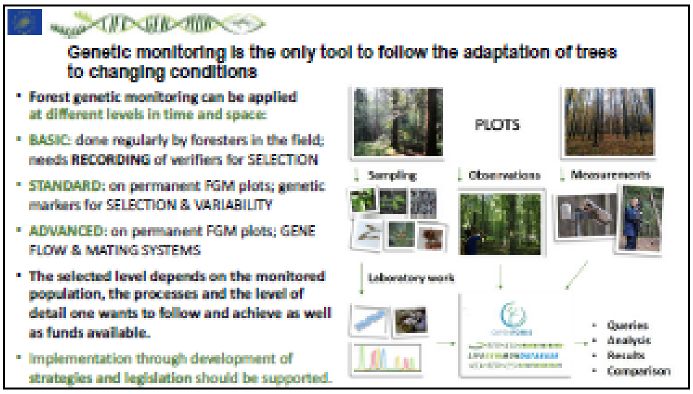

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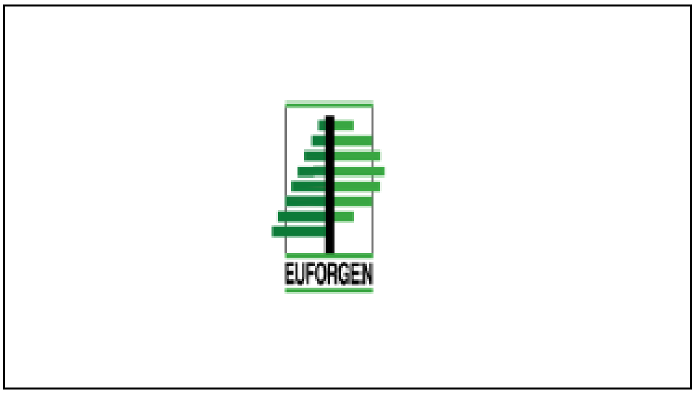

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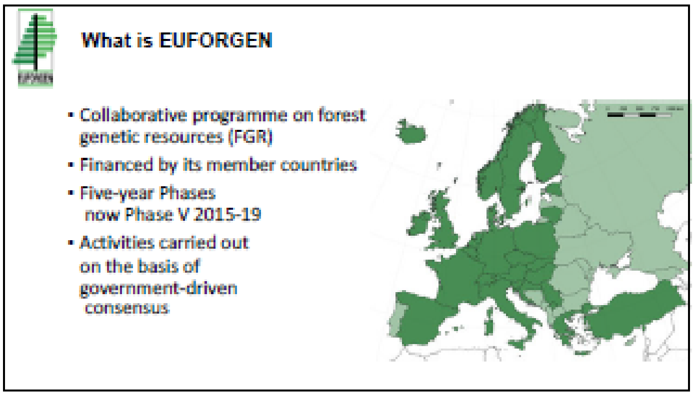

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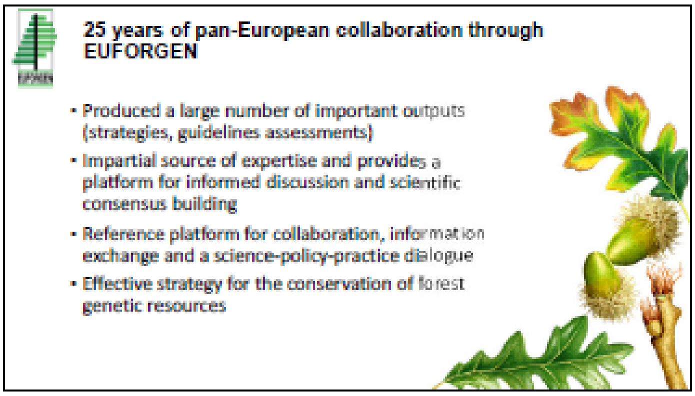

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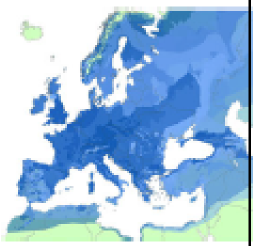
Recommendations with policy relevance

- Conserve forest genetic resources at all levels - key for the adaptation to climate change
- Facilitate the appropriate choices of forest reproductive material
- Monitor adaptation and the evolutionary potential of transferred forest reproductive material



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Wrap up of the main messages

Forest management is crucial for the conservation of forest genetic resources

natural regeneration can be insufficient to guarantee adaptation

Tools have been developed, still need to be tested and further improved through targeted research

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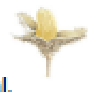
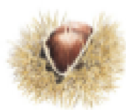
International cooperation

We need **regulating frameworks** to promote coordination among European countries (and neighbours) regarding **conservation of forest genetic resources and the use of forest reproductive material**.

Resources should be made available at the European level to ensure that transnational efforts can guide the **implementation of conservation and sustainable** forest genetic resources at country level, **as a strat to adapt to climate change**





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GENETIC RESOURCES
THE KEY TO ADAPTATION OF FORESTS TO GLOBAL CHANGE

Thank you

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