EUFORGEN

EUROPEAN FOREST GENETIC RESOURCES PROGRAMME

ENSURING FOREST RESILIENCE AND PRODUCTIVITY IN EUROPE'S CHANGING CLIMATE

RECOMMENDATIONS FOR POLICY AND PRACTICE IN THE PRODUCTION AND USE OF FOREST REPRODUCTIVE MATERIAL

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The European Forest Genetic Resources Programme (EUFORGEN) is an international cooperation programme that promotes the conservation and sustainable use of forest genetic resources in Europe as an integral part of sustainable forest management. Experts from member countries come together within EUFORGEN to exchange information and experience, analyse policies and practice, and develop science-based strategies, tools and methods to improve the management of forest genetic resources. EUFORGEN is hosted by the European Forest Institute and is funded by its member countries.
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EXECUTIVE SUMMARY

Forests cover more than a third of Europe's land surface and provide a multitude of ecosystem services and socioeconomic functions. They are vital for meeting climate targets, and for the transition to a sustainable, circular bioeconomy. However, climate change itself presents an acute threat to European forests, bringing with it a host of potentially devastating impacts, as well as uncertainties. To address this, forest management must be oriented towards increasing genetic diversity and accelerating genetic adaptation using suitable forest reproductive material (FRM).

The production of FRM involves a complex chain of actions—from the approval, establishment and management of basic materials, through seed collection, processing, storage, and propagation, to certification, trade, and transportation to end users. At each stage, procedures can inadvertently result in the use of inappropriate planting material, potentially leading to forest instability, a significant reduction in forest cover, and major losses to forest productivity. The regulatory instruments for FRM production and trade were initiated in the 1960s in recognition of the scale of international trade in FRM, and the main international legislative instruments for the certification and marketing of FRM have been in place since 1999 (Box 2). However, variations in the interpretation and implementation of these regulatory instruments varies significantly across Europe. Improved practices throughout the FRM production chain are needed, but they must be supported with appropriate policies, strengthened implementation of existing legislation, and capacity building.

This policy summary calls for national and regional policymakers to urgently consider (as applicable) three key recommendations to ensure the resilience, stability and productivity of Europe's forests in the coming decades:

1. **Review, enhance and strengthen the enforcement of national regulations relevant to FRM production and use.**

2. **Improve FRM production and use record-keeping, data transfer and data sharing.**

3. **Provide adequate investment to support and enhance all stages of the FRM production and use processes.**

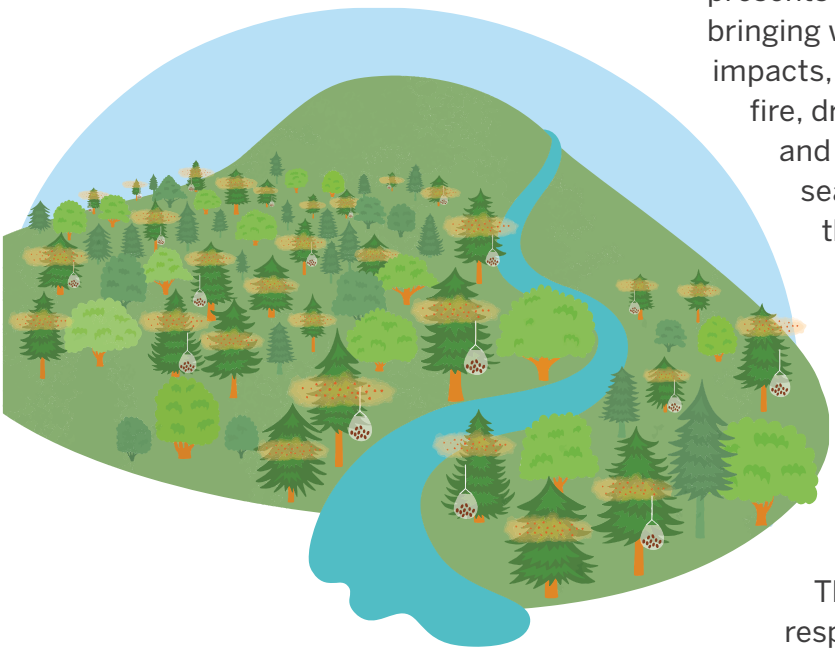
Photo: Roman Beliakov/Envato

INTRODUCTION

300,000 km^2
is the forested area of Europe that has expanded since the second half of the 20th century

The multiple functions of forests

Forests cover more than one third of Europe's land surface[1] and provide a multitude of ecosystem services and socioeconomic functions which are fundamental to meet several of the UN Sustainable Development Goals. Forests are essential for supporting most species found on land, for regulating services such as carbon sequestration, erosion control and water capture, for the production of goods, for creating jobs and preserving prosperous rural areas, and for people's health and wellbeing.



In the context of climate change, forests have become increasingly important to support countries in their efforts to reduce greenhouse gas (GHG) emissions and in the transition to a sustainable, circular bioeconomy (e.g., for biomass production as a renewable replacement for oil-based products). Their importance is reflected in a range of global and European policy and legislative instruments aimed at sustainable forest management with a view to building resilience and safeguarding their stability and productivity into the future.

Europe's forests at risk

The forested area of Europe has expanded by some 300,000 square kilometres since the second half of the 20th century—the largest proportional gain in tree cover of all continents[2]. At the same time, climate change presents a severe threat to European forests, bringing with it a host of potentially devastating impacts, as well as uncertainties. These include fire, drought, new and more severe pest and disease outbreaks, and changes in seasonal climatic events such as frost—the latter leading to shifts in the timing of vegetative processes such as bud burst and a higher risk of frost damage. Large plantations managed for product uniformity tend to have narrow genetic diversity and can therefore be at particularly high risk due to a lack of resilience.

The concept of forest resilience in response to climate change is not new and was brought to the fore in the earliest reports of the Intergovernmental Panel on Climate Change (IPCC), published more than 30 years ago. The message is clear and simple: scientists agree that the more diverse a forest is in terms of species and genetic diversity, the more likely it will be able to withstand the threats brought about by climate change. Combined

[1] FOREST EUROPE 2020. State of Europe's Forests 2020. foresteurope.org/wp-content/uploads/2016/08/SoEF_2020.pdf

[2] Biodiversa policy brief: *How natural forest expansion in Europe can offer cost-effective benefits to people* – biodiversa.org/1842

30 million

plants and 400 metric tonnes of seeds of the eight main forest tree species alone were traded annually in the EU between 2004–2014

with uncertainties in climate projections, this demands that forest management must be oriented towards increasing genetic diversity and accelerating genetic adaptation.

Building forest resilience

Forest regeneration, whether natural or artificial, is based on the availability and utilization of forest genetic resources (FGR)[3]. Natural regeneration relies on genetic diversity that already exists within forest stands, while artificial regeneration is carried out through seeding or planting material from other sources. Although close-to-nature silviculture and the active promotion of natural regeneration has been advocated as a possible management approach to allow forests to cope with climate change, scientists now know that the speed of climate change is outstripping the ability of tree populations to adapt solely by natural evolutionary processes, such as adaptation, gene flow and migration. Therefore, the exclusive use of natural regeneration in forestry may not be a suitable option in all cases.

The imperative for the use of artificial regeneration in forestry is indisputable when considering the catastrophic impacts of climatic conditions, pests and diseases on forest tree species. This demands the introduction of genetically suitable planting materials—some of which may need to be transferred from other localities. For example, in response to the large-scale decline in Norway spruce (*Pinus abies*) caused by drought and bark-beetle outbreaks, monocultures throughout Europe are gradually being replaced by stands which have species compositions appropriate for individual sites. Considering the rapid climatic changes already impacting Europe's forests, and the uncertainty that climate change brings for the future, there is a pressing need for forest managers to have the option of diversifying forest stands using artificial regeneration techniques—interventions that are dependent on genetically suitable and good quality forest reproductive material (FRM)[4], as well as an appropriate policy environment.

Sustainable forest management demands action on forest reproductive material

The trade in FRM is big business. During the period 2004–2014, some 30 million plants and 400 metric tonnes of seeds of the eight main forest tree species[5] alone were traded annually in the EU[6]. FRM marketing and trade are addressed in existing international legislative instruments which provide a regulatory framework for the certification of FRM and standardized procedures for the exchange of information and material (Box 2). However, variations in their interpretation at national level, inadequate enforcement, and short-term economic interests, are limiting the use of appropriate FRM in forestry and increasing the risk to Europe's forest biodiversity and productivity. The climate emergency not only demands greater emphasis on the use of FRM in forestry, but also on improvements to the production and use of FRM in line with an extensive body of scientific and practical

[3] Genetic material of forest trees that is of actual or potential use for humans.

[4] Seeds, seedlings or cuttings of trees and shrubs important for forestry, as well as for non-forestry purposes.

[5] Norway spruce (*Picea abies*), Scots pine (*Pinus sylvestris*), maritime pine (*P. pinaster*), beech (*Fagus sylvatica*), ash (*Fraxinus excelsior*), sessile oak (*Quercus petraea*), common oak (*Q. robur*) and northern red oak (*Q. rubra*)

[6] Jansen, S., Konrad, H. and Geburek. T. 2019. Crossing borders – European forest reproductive material moving in trade. *Journal of Environmental Management* 233, 308–320 DOI: 10.1016/j.jenvman.2018.11.079

knowledge, as well as in the framework of existing and developing legislative and policy instruments.

In the context of a strong evidence base, this policy summary explains the importance of FRM in forest establishment and management, outlines current risks and limitations in its production and use, summarizes the related policy landscape, and highlights the importance of record-keeping and information exchange. It calls for national and regional policymakers to urgently consider three key recommendations (Box 1) to improve the current situation to ensure the resilience, stability and productivity of Europe's forests in the coming decades.

Photo: Envato

Box 1. Key policy recommendations for improved production and use of FRM

1. Review, enhance and strengthen the enforcement of national regulations relevant to FRM production and use

1.1. Undertake expert reviews of national regulations relevant to FRM production and use to identify potential constraints and options for enhancement. In particular, reviews should consider:

1.1.1. Permitting forest managers to have the option of diversifying forest stands using artificial regeneration techniques.

1.1.2. Allowing the regulated movement of FRM to take account of the projected impacts of climate change.

1.1.3. The regulation of large-scale plantation forestry in line with national legislation.

1.1.4. The development of common standards on clonal plantation forestry that encourage the use of clonal mixtures and controls on clone status.

1.2. Regularly review and update, as applicable, phytosanitary regulations on the basis of up to date science-based knowledge.

1.3. Intensify and better coordinate official controls and inspections under phytosanitary regulations, Council Directive (1999/105/EC) and the OECD Forest Seed and Plant Scheme, to keep abreast with changing trade patterns and pathways for existing and new pests and diseases.

1.4. Ensure that the competence of official bodies and state forestry authorities to control FRM collection is recognized and executed.

1.5. Fully comply with regulatory procedures to fulfil basic material owner rights by facilitating the tracing of FRM throughout the production chain to the market.

2. Improve FRM production and use record-keeping, data transfer and data sharing

2.1. Ensure that the transfer of Information Documents between Official Bodies is carried out effectively, thus complying with Council Directive (1999/105/EC) and the OECD Forest Seed and Plant Scheme. When possible, the movement of tree seeds and seedlings destined for non-forest uses should be handled under the same rules.

2.2. Comply with the obligation of keeping the registers on basic material updated and to share them.

2.3. Provide data to and regularly report updates to FOREMATIS (applicable only to EU Member States), ensuring that data can be trusted and used as a basis for making decisions about the use of FRM.

2.4. Keep long-term records of FRM origin and performance in deployment stands, with a view to making this information available for sustainable forest management.

2.5. Gather and manage data on the collection of FRM for own use (i.e., for materials outside the scope of the marketing legislation), as well as provide guidelines on the importance of taking into account genetic diversity and adaptability for such users.

3. Provide adequate investment to support and enhance all stages of the FRM production and use processes – notably:

3.1. The development of science-based decision support tools for the transfer of FRM taking into account regional and pan-European predicted future climate scenarios to provide a sound basis for the use of non-local FRM.

3.2. Research to improve knowledge of the impact of management decisions at all levels of the FRM production chain.

3.3. Ongoing and new provenance trials and complementary approaches such as Adaptive Management[1].

3.4. Education and training programmes to help actors in the FRM production chain to comply with national policies and regulations.

3.5. Research to improve existing marker-based FRM certification methods.

[1] Geburek T., Kraigher H., Gömöry, D. and Wolter, F. 2021. Chapter 5, Keeping records of seed origin in order to improve forest management – bridging forestry and science. In: D. Gömöry, K. Himanen, M.M. Tollefsrud, C. Uggla, H. Kraigher, S. Bordács, P. Alizoti, S. A'Hara, A. Frank, G.F. Proschowsky, J. Frýdl, T. Geburek, M. Guibert, M. Ivanković, A. Jurše, S. Kennedy, J. Kowalczyk, H. Liesebach, T. Maaten, A. Pilipović, R. Proietti, V. Schneck, A. Servais, B. Skúlason, C. Sperisen, F. Wolter, T. Yüksel and M. Bozzano. *Genetic Aspects in Production and Use of Forest Reproductive Material: Collecting Scientific Evidence to Support the Development of Guidelines and Decision Support Tools*. European Forest Genetic Resources Programme (EUFORGEN), European Forest Institute. pp. 143–149. euforgen.org/publications/publication/genetic-aspects-linked-to-production-and-use-of-forest-reproductive-material-frm/

THE CHOICE OF FRM IS CRITICAL FOR SUSTAINABLE FOREST MANAGEMENT

In view of the increasing demand for forest goods and services, a substantial proportion of Europe's forests will need to undergo more intensive management. Procedures used in the establishment and management of forests can strongly influence the genetic structure of forest tree populations. Although from a commercial point of view, less stand variability means greater potential gain, a balance must be found between yield and forest resilience to address the risks posed by climate change. Vitally, the forestry sector must learn from the many historic failures related to the use of inappropriate FRM that have been demonstrated in Europe since the late 19th century.

Photo: Envato

Rapid climate change increases the prerequisite for assisted migration

Studies show that not all forest tree populations of local provenance are able to adapt to climatic changes—especially those at the rear edge[1] and ecological margins of a species' range. In fact, scientists have predicted that by the end of the 21st century, the ranges of the majority of European tree species will be negatively impacted by changes in local climatic conditions[2]. Assisted migration[3] using FRM of provenances fit for future climatic conditions is therefore likely to become increasingly important for ensuring forest resilience. For instance, a study of drought sensitivity and resilience in Scots pine (*Pinus sylvestris*) —a species affected by drought-related dieback— has shown that trees of Mediterranean provenance are better adapted to moderate drought than those from temperate continental regions[4]. Importantly, any assisted migration must take a multi-risk approach with regular assessment of adaptation measures.

Critically, under EU and OECD legislation[5] (Box 2), countries are obliged to establish Regions of Provenance of approved basic material (also referred to as 'seed zones'). However, this framework for FRM transfer may need to be complemented by the introduction of deployment

[1] The low latitude limit of a species' range.

[2] Mauri, A., Girardello, M., Strona, G. *et al*. 2022. EU-Trees4F, a dataset on the future distribution of European tree species. Scientific Data 9, 37. DOI: 10.1038/s41597-022-01128-5

[3] The intentional translocation of species, populations or genotypes to compensate for observed or future climate changes.

[4] Seidel, H., Schunk, C., Matiu, M. and Menzel. A. 2016. Diverging drought resistance of Scots pine provenances revealed by infrared thermography. *Frontiers in Plant Science* 7, 1247. DOI: 10.3389/fpls.2016.01247

[5] *Council Directive (1999/105/EC) of 22 December 1999 on the marketing of forest reproductive material* – eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A31999L0105 and the *OECD Scheme for the Certification of Forest Reproductive Material Moving in International Trade* – oecd.org/agriculture/forest/

Photo: Envato

Enrichment planting is a forest management approach to fill gaps in forests where natural regeneration has failed

areas[6] based on climate change scenarios (and data on performance when such data exist). Furthermore, restrictions on the movement of FRM between seed zones in some countries may be counter to the goal of using material of suitable provenance for forest regeneration. For transnational adaptation of forest ecosystems under climate change, future regulations need to take climate change into account and should make use of widely available genetic and phenotypic data to establish more science-based approaches.

FRM have important adaptive genetic potential

Enrichment planting is a forest management approach to fill gaps in forests where natural regeneration has failed, or to introduce new species into forest stands. It can be seen as an option to increase genetic diversity by facilitating the emergence of new genetic combinations and the spread of the best-adapted genotypes, as well as to secure the conservation of genetic diversity to enable long-term selection. However, adequate site-adapted choice of FRM is crucial to achieve this aim. Further, because the production time from planting to harvesting is dictated by the long biological cycles of trees, scientists and forest practitioners strongly recommend the use of genetically diverse FRM in plantations to improve their resilience over time—even if this could lead to a decline in productivity. Combined with appropriate management interventions, the adaptive genetic potential of the selected FRM is also vital to take account of the effects of local natural selection pressures.

The use of unregulated FRM carries a high risk

The EU and OECD legislation (Box 2) requires that FRM placed on the market must come from approved basic material[7] (Figure 1). However, since the legislation only applies to FRM produced for the market and on marketing itself, in some countries it is legal for forest owners to collect their own seeds for use in forest regeneration. This rule may sometimes also be extended to the management of state forests and this case, tens of tonnes of seed may be collected from neighbouring stands. As the use of FRM that is not registered in any of the basic material

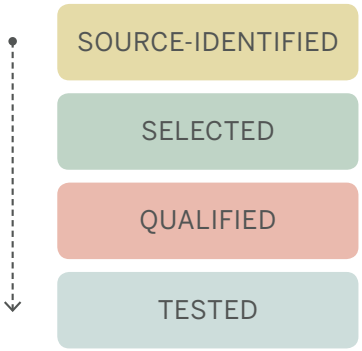


***Figure 1**. Categories of Forest Reproductive Material according to the Council Directive (1999) and the 'OECD Forest Seed and Plant Scheme' (OECD, 2018). The direction of the arrow indicates the selection level of the FRM.*

categories carries a high risk, foresters need to be informed about the importance of the genetic quality of the material they use.

In addition to forestry, tree seeds are collected and seedlings produced for several other purposes, including for planting on roadsides and in parks and gardens, and for Christmas tree production.

[6] Defined geographical areas suitable for the deployment of FRM of known origin (from specified stands, seed orchards or clones), taking into account the suitability of the material to survive, adapt and grow in current and predicted climatic conditions.

[7] Trees or vegetative material from which reproductive material is obtained.

Inappropriate planting material use can lead to forest instability, a significant reduction in forest cover, and major losses to forest productivity

This unregulated material may inadvertently (or even in some cases deliberately) be used as FRM, posing several risks, such as poor adaptation to the environmental conditions of the site, the introduction of undesirable traits, and losses due to the introduction of pests and diseases. It is the duty of official bodies in each country to prevent the trade of material of unknown origin.

Improvements to FRM production chains are needed

The production of FRM involves a multifaceted chain of actions—from the approval, establishment and management of basic materials, through seed collection, processing, storage, and propagation, to certification, trade, and transportation to end users (Figure 2). At each stage of this chain, procedures can inadvertently result in the use of inappropriate planting material, which in the long term can lead to forest instability, a significant reduction in forest cover, and major losses to forest productivity. Some examples of limitations in the FRM production chain and recommended solutions are given in Box 3.

While these problems can be alleviated with improved practices throughout the production chain, they must be supported with appropriate policies and strengthened implementation of

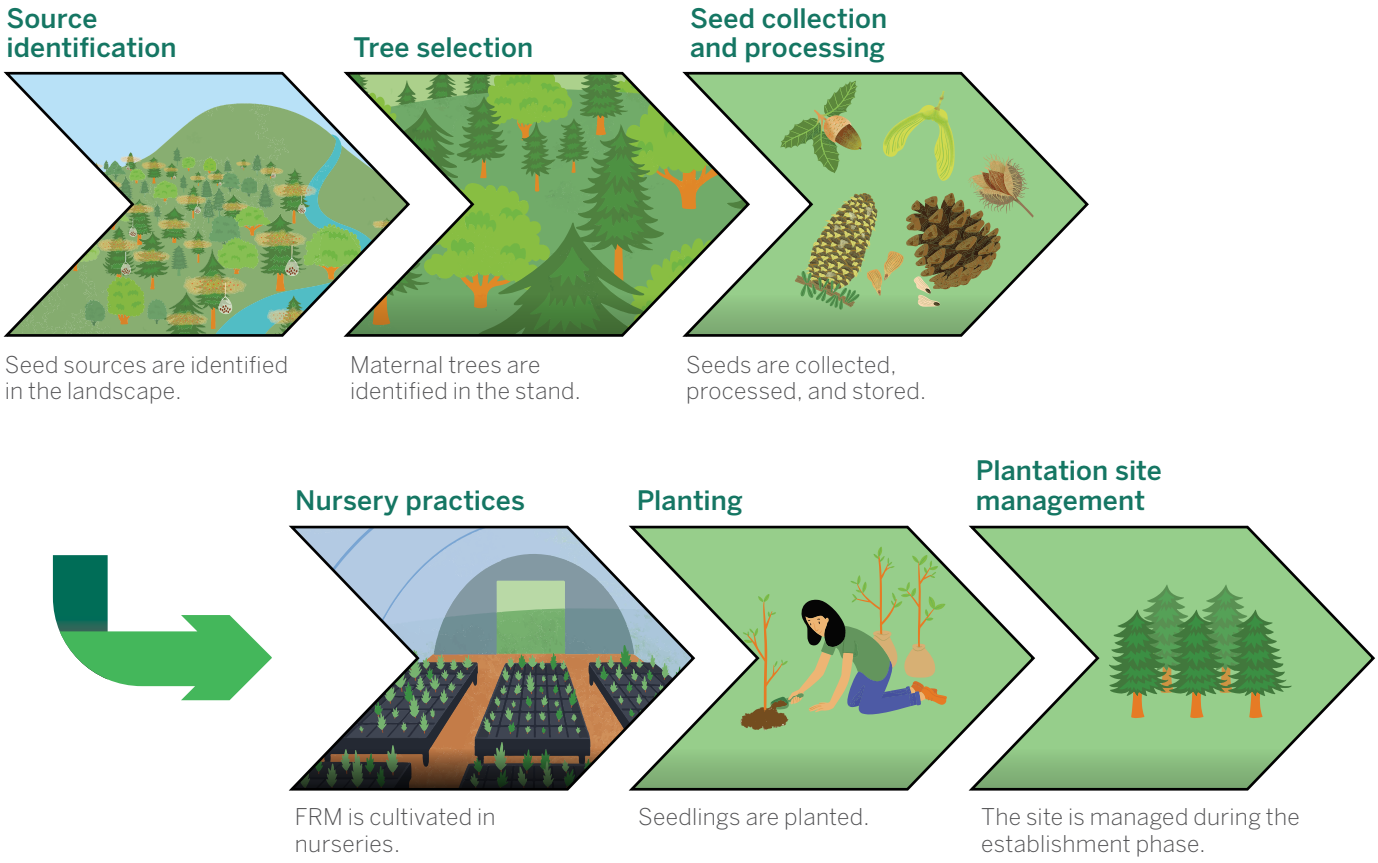


***Figure 2**. The FRM production and use chain.*

existing legislation. This may be achieved with better enforcement and enhanced monitoring, as well as by capacity building and promotion of good practices among the involved stakeholders. However, in some cases it may be necessary to review and amend national regulations—for example, regarding the criteria and thresholds for the minimum requirements of different types of basic material.

Acknowledging that a degree of flexibility is required to take account of national particularities and changing needs, national reviews of current practices for the production and use of FRM and their impacts on forests (supported with sufficient financial resources and appropriate expertise), and measures to improve these practices where required, would be highly beneficial. Although research on the impacts of FRM production and use on forest resilience, stability and productivity is ongoing, there is already a substantial knowledge base that provides a benchmark against which such reviews can be undertaken.

The regulatory framework for FRM production and use

The regulatory instruments for FRM production and trade (Box 2) were initiated in the 1960s in recognition of the scale of international trade in FRM. Today, the rapid rate of climate change heightens their importance due to the urgency to increase forest resilience and ensure their stability and productivity into the future. However, due to the very different circumstances of European countries regarding the type, extent and use of forests and their importance to the national economy, as well as available financial resources and technical capacity, the interpretation and implementation of the regulatory instruments varies significantly throughout the region.

For example, EU Member States are allowed to impose more stringent requirements for the production and marketing of FRM in the category 'source identified'[8] than the minimum requirements specified in Council Directive (1999/105/EC). Due to the low associated costs, this category of FRM is traditionally used in some countries for afforestation of large clear-cut areas. However, recognizing the limitations of the minimum requirements laid out in the Directive with regard to genetic diversity and future adaptability, some Member States have specified more rigorous criteria in national legislation, while in others, this type of material is only allowed for a few species or is not accepted at all. Procedures for the approval of basic material for certification in the highest category of FRM, 'Tested'[9], also varies considerably between countries, as does the amount of material tested. Council Directive (1999/105/EC) applies general wording when describing testing procedures and EU Member States implement the rules differently according to their national legislation, and in practice to their specific needs.

Importantly, although regulations have been in place to apply protective measures against the introduction and spread of organisms harmful to

[8] The minimum FRM standard permitted. Basic material which may be either a seed source or stand located within a single region of provenance. The location and altitude of the place(s) from which FRM has been collected must be recorded. Little or no phenotypic selection has taken place.

[9] Basic material consisting of stands, seed orchards, parents of families, clones or clonal mixtures. The superiority of the reproductive material must have been demonstrated by comparative testing, or an estimate of the superiority of the reproductive material calculated from the genetic evaluation of the components of the basic material.


Photo: Adobe Stock

International trade in FRM is likely to increase due to an internationalized market and increased use of non-local FRM in assisted migration to improve forest resilience, stability and productivity

plants in the EU for more than two decades (Box 2), they have not been sufficiently effective to prevent the introduction and spread of pests and diseases of forest tree species via transport and trade. Official controls and inspections under phytosanitary regulations need to be continuously updated with science-based knowledge, as well as intensified and better coordinated to keep in pace with changing trade patterns and pathways for existing and new pests and diseases.

Because of the recognized vital role of genetically suitable and good quality FRM in forestry, implementing stringent controls on its production and use, along with the provision of education and advice for practitioners, is of major significance in meeting the goals and provisions of a number of other policy and legislative instruments aimed at the conservation and sustainable use of FGR, as well as of biodiversity in general. Most notably, these are: the Global Plan of Action for the Conservation, Sustainable Use and Development of Forest Genetic Resources (GPA-FGR)[10]; Resolution S2 of the Forest Europe Ministerial process[11]; the EU Biodiversity Strategy for 2030[12] and New EU Forest Strategy for 2030[13]; the recently promoted Forest Genetic Resources Strategy for Europe[14]; and the Proposal for a Regulation of the European Parliament and of the Council on nature restoration[15]. Therefore, effective implementation of the stipulations of Council Directive (1999/105/EC) and of the OECD Forest Seed and Plant Scheme will in turn assist countries in meeting their obligations under this wider range of policy and legislative instruments.

National record-keeping and information exchange are vital to support Europe-wide use of appropriate FRM

Due to an already increasingly internationalized market, as well as the anticipated increased use of non-local FRM in assisted migration to improve forest resilience, stability and productivity in the light of climate change, the international trade in FRM is likely to increase. To support the forestry sector in decision-making on the use of FRM, the sharing of trusted data is vital—in turn demanding appropriate record-keeping and easy data exchange.

Under EU and OECD legislation (Box 2), national authorities are obliged to maintain national registers of approved basic material. Access by all European countries to information held in national registers would greatly enhance the

[10] fao.org/policy-support/tools-and-publications/resources-details/en/c/469497/
[11] foresteurope.org/publications_type/resolution-s2-conservation-of-forest-genetic-resources/
[12] eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0380
[13] eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021DC0572
[14] euforgen.org/publications/publication/forest-genetic-resources-strategy-for-europe/
[15] environment.ec.europa.eu/publications/nature-restoration-law_en

marketing and use of suitable and genetically diverse FRM throughout the region. For EU Member States, FOREMATIS[16] holds information from national registers about all existing FRM categories and types for all listed species. It is an important tool for sharing information, including for stakeholders in non-EU countries who are able to view the data. EU Member States are required to regularly report updates to FOREMATIS, and other countries in Europe —including OECD members— are strongly encouraged to comply with their obligation to keep national registers on basic material updated, as well as to share these data.

A permanent record of the origin of FRM used at individual sites could serve as a valuable source of information for evaluating its long-term performance and for informing the future selection of appropriate materials for localities with similar environmental conditions. This is particularly significant since decision-making on the choice of FRM to use could be based on records of tried and tested material, ensuring its suitability for the site conditions and thus a higher success rate. However, tracing the origin of FRM used to establish forest stands is currently challenging due to a lack of record-keeping by forest owners and managers.

A potential solution lies in the creation of digital records of the origin and chain of custody of FRM used at planting sites, linked to provenance performance. This would greatly benefit sustainable forest management in Europe, allowing for the selection of FRM based on data-driven decisions—ultimately improving forest health and productivity. Thus, in addition to maintaining national registers of approved basic material, the creation of a comprehensive European digital record of FRM origin and performance could revolutionize forest management practices.

Records of origin may also be used to keep track of international FRM transfers and for regulating or even restricting the use of FRM. Such information is also beneficial for the assessment of forest distribution and biodiversity as required by international policy instruments such as the GPA-FGR, as well as for allocating subsidies under instruments such as the European Agricultural Fund for Rural Development (EAFRD)[17].

In light of the need for traceability of the origin, movement and use of FRM, options for developing a long-term archive for geo-referenced[18] information on the origin and use of FRM are being investigated in the context of the EU-funded OptFORESTS project[19]. Such a voluntary mechanism for data sharing could allow the entire production and use chain to be recorded, and would enable FRM provenance performance assessment under different environmental and management conditions. In turn, this would support the development of transfer guidelines indicating the most appropriate material for individual sites and their functions.

[16] ec.europa.eu/forematis/

[17] agriculture.ec.europa.eu/common-agricultural-policy/financing-cap/cap-funds_en#eafrd

[18] A system for recording precise geographic locations using map coordinates.

[19] optforests.eu

WHAT ARE THE POLICY IMPLICATIONS?

The issues addressed in this policy summary highlight an urgent need for actions to improve the FRM production chain and to facilitate the use of FRM with a view to ensuring the resilience and stability of Europe's forests and to supporting a sustainable European forestry sector. To achieve this, the interpretation and implementation of policy and legislation related to FRM production and use needs to be strengthened and supported, as applicable, with enhanced national regulations, better enforcement, and improvements to record-keeping, data transfer and data sharing. Further, actors in the FRM production and use chain need to be supported through education and training (and appropriate funding, as applicable) to help them comply with national policies and regulations. Three overarching key policy recommendations for consideration by policymakers are:

1. Review, enhance and strengthen the enforcement of national regulations relevant to FRM production and use.

2. Improve FRM production and use record-keeping, data transfer and data sharing.

3. Provide adequate investment to support and enhance all stages of the FRM production and use processes.

These recommendations are presented in detail in Box 1 earlier in this policy summary.

This policy summary has been synthesized from:

D.Gömöry, K.Himanen, M. M.Tollefsrud, C. Uggla, H. Kraigher, S. Bordács, P. Alizoti; S. A'Hara, A. Frank, G. F. Proschowsky, J. Frýdl, T. Geburek, M. Guibert, M. Ivankovi, A. Jurše, S. Kennedy, J. Kowalczyk, H. Liesebach, T. Maaten, A. Pilipovi, R. Proietti, V. Schneck, A. Servais, B. Skúlason, C. Sperisen, F. Wolter, T. Yüksel and M. Bozzano. 2021. *Genetic aspects linked to production and use of forest reproductive material: Collecting scientific evidence to support the development of guidelines and decision support tools.* European Forest Genetic Resources Programme (EUFORGEN), European Forest Institute. 216 p.

Box 2. FRM marketing and trade – the regulatory framework

FRM marketing and trade occurs within the regulatory frameworks of two main international legislative instruments: the 'OECD Scheme for the Certification of Forest Reproductive Material Moving in International Trade' (OECD Forest Seed and Plant Scheme)[1] and 'Council Directive (1999/105/EC) of 22 December 1999 on the marketing of forest reproductive material' (Council Directive (1999/105/EC)[2]. They define four broad categories of FRM that are recognized for certification and establish minimum requirements for the approval of six different types of basic material[3] intended for production and use (Figure 1). More stringent requirements can however be stipulated in national legislation implementing Council Directive (1999/105/EC) by individual countries. Although the Directive applies only to EU Member States, its provisions are widely adopted by non-EU countries in Europe.

The OECD Forest Seed and Plant Scheme and Council Directive (1999/105/EC) stipulate the creation of national registers of basic material. 'Commission Regulation (EC) No 1597/2002 of 6 September 2002 laying down detailed rules for the application of Council Directive 1999/105/EC as regards the format of national lists of the basic material of forest reproductive material'[4] defines the standards for the national registers and specifies that EU Member States make their lists available on request to the Commission and other Member States in a digital format. For this purpose, the EC established FOREMATIS — the EC Forest Reproductive Material Information System[5].

Commission Regulation (EC) No 1598/2002[6] defines a standardized procedure for the exchange of information on the marketing of FRM by registered suppliers between EU Member States. This Regulation has the objective of establishing a control system—in accordance with Council Directive (1999/105/EC)—for ensuring FRM from individual units of approval or lots remains clearly identifiable through the entire process from collection to delivery to the end user.

Phytosanitary measures in the EU are regulated under Council Regulation (EU) 2016/2031[7] on protective measures against pests of plants (including pathogenic agents), which was adopted in 2019 and repeals Council Directive 2000/29/EC[8] on protective measures against the introduction and spread of organisms harmful to plants or plant products. Council Regulation (EU) 2016/2031 not only focuses on preventing the introduction and spread of plant pests, but also on broadening the requirements for importing plant material into the EU and its movement within the

[1] oecd.org/agriculture/forest/
[2] eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A31999L0105
[3] Trees or vegetative material from which reproductive material is obtained.
[4] eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32002R1597
[5] ec.europa.eu/forematis/
[6] eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32002R1598
[7] eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32016R2031
[8] eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A32000L0029

territory, including stipulating new obligations and responsibilities for professional operators.

Most countries in Europe (both EU and non-EU members) are also Contracting Parties (CPs) to the International Plant Protection Convention (IPPC)[9]—an intergovernmental treaty that aims to protect the world's plant resources from the spread and introduction of pests, and promoting safe trade. The Convention introduced International Standards for Phytosanitary Measures (ISPMs) as its main tool to achieve its goals and establishes several reporting obligations of the CPs.

[9] ippc.int/en/

Box 3. Examples of limitations and recommended solutions in the FRM production chain

Seed collection

Repeated collection of seeds from only a small number of trees in seed stands for use in reforestation is commonplace, either due the phenotypic superiority of the trees (e.g., based on growth rate or stem quality) or because of ease of access. Such practices are highly likely to result in reduced genetic diversity in the reproductive material and consequently an inability of reforested areas to adapt to the impacts of climate change. While the underlying population genetics governing the optimum collection of genetically diverse seed samples is complex and varies from one species to another, a relatively simple procedure has been recommended by scientists and practitioners which can significantly improve the outcome: the uniform harvesting of as many trees as possible across the whole area of a seed stand and mixing of seed lots collected from one stand in different crop years.

Use of clonal material

While the use of clonal material in forestry has the advantage of generating more uniform products, it carries with it high ecological and economic risks due to a lack of genetic diversity in the material. In particular, large monoclonal plantations can be destroyed by pest or disease infestations, as well as by extreme weather events such as heatwaves and drought. This vulnerability in clonal stands can be reduced by introducing a greater number of genotypes in clonal mixtures—a relatively simple amendment to a commonly used forestry practice. This adjustment recognizes the need for a trade-off between the short-term economic gains achieved through the simplification of forestry practices (resulting in potentially lower forest resilience and subsequent losses in productivity), and an increase in the adaptability of forests to climate change, resulting in greater resilience, stability and productivity in the long term.

Nursery practices can impact survival and genetic diversity of cultivated forests, affecting seedling development even after planting


Photo: Envato

Seed handling

While seed handling practices do not inevitably lead to loss of genetic diversity, it is important for practitioners to be aware of the risks and to use methods to minimize them. For example, the commonly used practice of seed fractioning (i.e., sorting seed from a single lot into weight or size fractions to market homogenous sub-lots) can result in the marketed seed lots having differing properties and vigour, different genetic profiles, and potentially reduced genetic diversity, despite being identified under the same Master Certificate. In accordance with Council Directive (1999/105/EC), all seed lots must be kept separate during processing. However, some mixings are permitted, such as between seeds sourced from two or more seed stands within a Region of Provenance or those collected from the same basic material in different years. In making use of this legal opportunity, the genetic diversity of these marketed seed lots could easily be increased.

Nursery practices

The effects of nursery practices on seedling survival and genetic diversity of cultivated forests may be noticed after out-planting, as production practices may, for example, affect the growth rhythm of the seedlings. In addition, the desire for both uniform germination and seedling morphology in practical seedling mass production encourages limited genetic diversity. Nursery practices are diverse and seedling production often takes place on a scale and in conditions that make control difficult. However, due to the potential impacts of procedures (from the selection of seed lots, through germination, pest management and fertilization practices, transplantation, culling, and seedling storage), as well as the production environment itself on the genetic diversity in planted forests, such procedures should be carefully reviewed and adjusted to minimize risk.

Certification

Misgivings about the validity of FRM certificates repeatedly arise and there have been some past cases of FRM mislabelling which have become public. Due to intensified trading activities across Europe, the traceability of FRM lots needs to be improved, involving tighter control and better management of accompanying documents and use of control tools by national authorities. In addition to a better enforcement of existing regulations, representatives from forest owners, private enterprises and inter-trade organizations from many European countries, together with members of research institutes and universities, have clearly ascertained the necessity for further development in the field of marker-based verifications of FRM origins. Genetic markers (biochemical and molecular) offer possibilities for more precise and efficient control on the basis of comparison of the genetic composition of seed stands, seeds and seedlings within a traceability system. Such systems have already been established in some countries, but further research to improve existing marker-based certification methods has been recommended.

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