

Forest Reproductive Material

Basic knowledge



The Forest Reproductive Material (FRM) Module is intended for people planning reforestation, afforestation and forest restoration initiatives, policymakers developing strategies for the conservation of forest reproductive material, and others interested in the use and conservation of high-quality FRM and the benefits of such use and conservation.

The module highlights key issues in the management of FRM and provides links to relevant tools and cases.

The term forest reproductive material, or FRM, encompasses seeds, plant parts (e.g. cuttings and scions) and plants raised by means of seeds or parts of plants including plants propagated *in vitro*. Knowledge of FRM – such as genetic and morphologic variation, reproductive biology, seed biology and storage, and plant propagation (by seed or vegetative means) – is essential for sustainable forest management in both natural and planted forests. In planted forests, for example, an adequate knowledge of these aspects will help ensure the use of appropriate techniques in seed source selection; seed collection, testing and storage; seedling production; and matching FRM with the environmental conditions of a planting site.

It is vital that adequate FRM management systems are in place for afforestation, reforestation and forest restoration projects. Such systems will involve a range of stakeholders, such as national tree seed centres and policymakers; private-sector bodies of various sizes, such as seed companies, seed dealers and tree nursery enterprises; local communities; and managers of forestation programmes and projects.

The management of FRM involves, among other things:

- the identification of appropriate species, provenances and individuals as sources of FRM;
- FRM collection and procurement;
- FRM handling and storage; and
- seedling production and transport.

Forest reproductive material contributes to SDGs:



Related modules

- [C&I: a tool for enhancing SFM](#)
- [Forest genetic resources](#)
- [Forest restoration](#)
- [Management of planted forests](#)
- [Silviculture in natural forests](#)

In more depth

In any tree-planting endeavour, it is essential to start with the right reproductive material. Unfortunately, there are many examples worldwide of forest regeneration programmes that failed because inadequate attention was given to FRM.

Purposes of FRM programmes

Conservation of genetic diversity. The role of FRM in the conservation of genetic diversity will depend on whether such conservation is to be *in situ* or *ex situ*. In *ex situ* conservation, collected FRM should be well documented, with information recorded on, for example, the location of stands from which the FRM was obtained, the number of trees in each stand harvested for their seeds (and ideally the location of each harvested individual), and a range of ecological and soil parameters. Seeds should be identifiable to their parent trees. Where possible, voucher specimens of fruits and leaves should be collected from each seed tree to ensure that its species has been identified accurately.

Appropriate knowledge of seed physiology and seed handling is required to ensure that seeds can be conserved in the long term. Seed-quality indicators such as moisture content, purity and viability should be assessed.

Natural forest management. Natural forest management aims to optimize the natural seeding and regeneration of desired species; for this, knowledge of the reproductive biology of those desired species is important. In some natural forests and under certain management regimes, seed may need to be collected and sown inside natural forests (sometimes called “direct seeding”), or seedlings raised in nurseries for planting in the forest (sometimes called “enrichment planting”), to assist regeneration processes. Good silvicultural knowledge and practical expertise is important for the success of such actions.

Large-scale plantings. High-quality FRM is essential to the success of any tree-planting endeavour – whether it is for the rehabilitation of degraded land, the commercial production of wood fibre, conservation, or any other purpose. Attention should therefore be paid to the institutional context, and capacity building may be required. Large-scale projects will require large quantities of FRM: there may be a need to establish national or subnational tree seed centres, or to reinforce existing ones.

Community forestry. In community forestry and agroforestry, local communities or seed dealers can be encouraged to contribute at different points in the FRM supply system. Local communities and individual farmers, for example, should be involved to the greatest extent possible in seed stand management, seed collection and cleaning, and nursery activities, among other things. Participatory approaches and the use of indigenous knowledge will not only ensure that local people are fully involved, they are also most likely to yield results that are efficient, sustainable and well-adapted to the local context.

Choosing the right FRM

Environmental context. The performance of FRM in the field will depend to a large extent on how well it is matched with the environment; information on the biophysical and ecological conditions in an area in which a reforestation or afforestation programme is to be implemented is therefore essential. Climatic information on FRM can be divided broadly into that concerned with tropical and subtropical species and that concerned with temperate species. Many developing countries are in the tropics, and much current work on FRM aims to provide information geared towards these countries. However, many principles and practices are applicable in both regions.

Species and provenance trials. People wanting to initiate an afforestation, reforestation or forest restoration programme face a wide range of choices in the species they plant. Moreover, many species span wide variations in geography and climate and are therefore likely to have high genetic variation that can be grouped into “provenances” – populations of a species growing in the same area of origin (and therefore exposed to similar environmental conditions). For species with a large number of provenances, provenance trials may be required to select the most suitable for use in a particular area.

To provide information on the most appropriate species or provenances for a target location, small quantities of a range of well-documented FRM, ideally certified to be of high physical and genetic quality, should be propagated and planted in the field under strictly controlled conditions; these are known as species or provenance trials.

Identifying the desired products and environmental services. Before embarking on a programme involving tree-planting or direct seeding, it is essential to know what the trees will eventually be used for. There are many examples of tree-planting programmes in which the end-use was undecided, unknown or inadequately planned at the time of implementation, with the end result that sometimes thousands of hectares of planted forests have little or no economic or environmental value. In some cases, non-native species have become invasive, leading to substantial unforeseen costs that have outweighed any benefits the plantations might have brought. Therefore, it is important that the goods and environmental services expected of the planted forests are clearly defined and the appropriate FRM for these purposes

selected.

Many planted forests will be established for multiple purposes, producing products such as lumber, pulpwood, fuelwood, construction poles and a range of non-wood forest products such as fodder, bark, fruits, oils, dyes, medicines and spices. In addition, planted trees and forests will provide environmental services related to, for example, soil and water protection, carbon sequestration and biodiversity conservation, which may be planned for or incidental. Many sources of information exist on the potential and actual uses of a wide range of tree species.

The FRM selection process

The process to select species and provenances can commence once the context and end-uses have been defined. It involves the following four major steps:

1. The species to be planted is chosen on the basis of the best available knowledge of their natural habitat and biological and reproductive characteristics and the extent to which they are suited to the conditions of the planting site. In other words, the seed zonation principle – Use FRM within the same seed zone (or region of provenance) – should be applied to the greatest possible extent. As a general rule, species that are native to the local area should be used in preference to non-native species, although the extent to which this is feasible will depend on the purposes of the planting activity.
2. Existing species, provenance, clonal or other trials, and the success of the FRM used in other plantings on similar sites, can be used to gauge how different FRM will perform. Information may be available in, say, species monographs or research datasets that could be consulted to assist selection. Long-term data should be used to the greatest extent possible to allow for a wider range of conditions.
3. Regardless of what information already exists, there may be a need to confirm decisions on FRM (especially where large-scale plantings are envisaged) by carrying out species or provenance trials of the proposed FRM in the field. This is because many unforeseen factors could affect performance, such as pests, drought, soil salinity or acidity, and the incidence of weeds. Ideally, such trials should continue until the trees reach the stage of generating the goods and environmental services for which they were planted, although the long timeframes involved may prohibit this.
4. In conducting such field trials, it is important to obtain the FRM from a reputable supplier and to apply the principles and practice of applied research.

An important issue to consider is whether local or introduced species should be used. Species such as eucalypts, pines and teak form the bulk of commercial forest plantations worldwide, mostly outside their natural ranges. The decision to use such species should take into account environmental, social and cultural issues as well as the economic goals of the planted-forest project. The use of introduced species can lead to potentially serious problems, such as invasiveness (e.g. introduced species assuming dominant roles in landscapes at the expense of native species) and the contamination of local gene pools.

The final step in selecting the material is to decide on the most appropriate reproductive material (e.g. seeds, cuttings or lab-based clonal material).

Seed collection and distribution

Once a decision has been made on the species and provenances to be used, the FRM needs to be procured in a way that ensures high quality and sufficient quantity. There are many factors to consider, particularly if the seeds are to be collected in the field or purchased from a dealer. Buying (and selling) FRM requires a good understanding of, among other things, the rules and regulations in force and the documentation needed. Once the FRM has been obtained, considerable effort may be needed to maintain its quality and to ensure that it is ready for use when it's required.

Scheduling. Collecting seeds in the field requires a good knowledge of fruiting seasons, as well as adequate planning to ensure that sufficient mature seeds are available for propagation. In some cases, seeds may need to be collected several years in advance of their use because some trees may not produce seeds annually, or seeding may not occur during extended droughts or when forests are otherwise under stress.

Estimating quantities. It can be difficult to accurately estimate the quantity of seeds required for a planting programme. Such estimation is best done by working backwards: that is, decide on the area to be planted and the stocking rate and then estimate planting mortality, nursery seedling yield, seed germination rates, seed yield per fruit, fruit yield per tree, and, in the forest or seed orchard, the number of seed trees per hectare. Errors in estimating any of these parameters will be compounded, so reliable data should be used to the greatest possible extent.

Access to trees. The harvesting of fruits, seeds or vegetative propagative material from trees in natural stands is potentially difficult,

dangerous and time-consuming. Characteristics that make species attractive as parent trees, especially for the production of lumber (e.g. straight bole, light branching and fast growth rates), often make their crowns difficult to reach. A wide range of techniques has been developed to overcome these problems, such as tree felling; the use of mountaineering techniques (for scaling trees) and helicopters; and rifles (to bring seed-bearing branches to ground). Careful consideration must be given to training and providing adequate safety measures for people involved in seed-collecting – their lives may depend on it.

Budgeting. Given that the timing and yields of seeds can be difficult to predict, seed-collecting budgets should be sufficiently flexible to ensure that adequate funds are available at relatively short notice. Rigid administrative rules and procedures can make this difficult, however.

Seed suppliers. FRM is often available from commercial firms and other institutions. It is important to use those that reliably provide material of adequate physical and genetic quality and with appropriate documentation. Other users of FRM can be a valuable resource in recommending good suppliers. In some countries, research and development institutions have the capacity to supply high-quality FRM, but usually in small quantities. The World Agroforestry Centre manages a [directory of seed suppliers](#).

Documentation. Seed collections should be properly documented to provide users with accurate information on the geographic location of seed sources, the number of trees collected from, genetic quality (for identified seed sources or stands, selected seed stands and qualified seed orchards), the date of collection, and other parameters. In documenting a seed collection, the standards of the Organisation for Economic Co-operation and Development's [Schemes for the Certification of Forest Reproductive Material Moving in International Trade](#) should be applied. All FRM, especially that which is being traded internationally, should be accompanied by certificates of genetic quality (confirming the species and geographic source, at a minimum), and physical quality (such as number of seeds per kilogram, purity and germination percentage). Such certificates can be issued by the supplier alone or according to a nationally or internationally recognized certification scheme. Phytosanitary certificates are obligatory to ensure that the FRM is not contaminated by insects, fungi or other kinds of pest. A further document called a material transfer agreement may need to be issued, the aim of which is to protect the rights of the original providers or guardians of the FRM.

Catalogues and prices. Suppliers may provide catalogues and certificates in either hard copy or electronic form. Users should ensure that the data made available by suppliers are sufficient to ensure that the offered FRM is of sufficient quality. Compared with the overall cost of planting programmes, the cost of seeds and other FRM is not high, and it would be false economy to buy cheap, poor-quality FRM. On the other hand, overpricing is possible, too, and potential buyers should compare prices from a range of sources to safeguard against this practice.

Packaging and transport. The movement of traded FRM may take considerable time, and the FRM may be subject to conditions that are adverse for maintaining viability. It is therefore important to ensure that packaging is adequate, that carriers are aware of the nature of the material, and that the recipient is notified of dispatch and arrival so that expeditious delivery can be arranged. A lack of attention to this part of the process may result in the arrival of dead or mouldy material.

Seed handling and testing

Reception and registration. It is important that any programme involving the use of FRM – from small-scale to large-scale, and from commercial plantation enterprises to agroforestry projects – keeps adequate records of the FRM it handles and uses. Information that should be recorded includes: source; initial quality (purity, germination) and quantity; treatments to which the FRM is subjected; the results of germination tests while under storage; the storage regime; distribution (e.g. quantities and recipients); and locations at which the FRM has been used in the field. A wide range of data-recording forms and software is available to assist the record-keeping process.

Processing. Collected seeds usually need to be extracted from fruit, which may be fleshy or dry, and then cleaned and dried where necessary, with due care to avoid reducing physical and physiological quality. A wide range of techniques has been developed for this task; various types of small-scale machinery are also available, although in many cases simple manual methods are adequate.

Storage. Trees may produce seeds irregularly, and harvesting should be maximized in good seed years and the seeds maintained in a viable state until they are required. Depending on the purpose to which the material will be put (e.g. in planting programmes or for genetic conservation), FRM may need to be stored for a relatively short period (e.g. less than one year) or in the long term (possibly for decades).

Seeds can be classified into two basic “storability” types related to the natural habitat of the species. “Orthodox” seeds store best in a dry and cool environment, and “recalcitrant” seeds need to be kept moist and may not withstand cooling; research indicates that there is also a wide variety of subtypes of these two broad types. Considerable information is available on storage techniques, and research is ongoing to improve the storability of recalcitrant seeds. The use of ultra-low temperatures for storage (cryostorage) is being developed for certain FRM. On the other hand, simple systems suitable for community forestry are often adequate. Seed storage involving sophisticated controlled-

environment approaches may be essential for long-term gene conservation.

Seed-quality assessment. Knowledge of the physical, physiological and phytosanitary quality of seeds is important for monitoring their collection, processing, storage and distribution and for deciding on the propagation techniques to be used in the nursery. Seed laboratories and storage facilities form the core of many national tree seed centres, allowing testing on samples from seed lots. The main characteristics by which seed quality is assessed are usually: seed weight (e.g. seeds per kilogram); purity; moisture content; germination percentage; and vigour. Simple equipment can be used for assessing many of these characteristics but, for some, precision equipment such as balances and incubators may be required. New techniques are being developed to measure characteristics such as embryo development and vigour. The [International Seed Testing Association](#) is a good source of information on the techniques of, and rules for, seed-quality assessment.

Treatment. Seeds may need to be treated to improve storage, germination and field survival. Possible treatments include dusting seeds with a fungicide or insecticide prior to storage, coating seeds with an insect repellent for direct sowing, and subjecting seeds to various processes that help break physiological or physical dormancy (e.g. heat treatment or the mechanical breakage of impermeable seed coats). Some species require inoculation with mycorrhizae to ensure vigorous seedling growth.

Distribution. The distribution of FRM to users should be recorded to ensure traceability. Traceability is essential for the proper evaluation of the quality of the FRM and its performance in the field.

E-learning

[Planning seed and seedling supply for forest and landscape restoration](#)



This course explores how to plan seed and seedling supply for forest and landscape restoration (FLR). This includes the importance of considering seed and seedling origin and genetic quality, the reproductive and supply chain bottlenecks that reduce genetic diversity or adaptive capacity, and ...

Further learning

FAO. 2004. [*Forest genetic resources no. 31*](#). FAO, Rome.

FAO. 2002. [*Forest genetic resources no. 30*](#). FAO, Rome.

FAO, FLD & IPGRI. 2004. [*Forest genetic resources conservation and management. Vol. 3: In plantations and genebanks \(ex situ\)*](#). International Plant Genetic Resources Institute, Rome, Italy.

Credits

This module was developed with the kind collaboration of the following people and/or institutions:

Initiator(s): Albert Nikiema - FAO, Forestry Department

Contributor(s): Oudara Souvannavong - FAO, Forestry Department

