Sustaining and Developing Ireland's Forest Genetic Resources

An outline strategy

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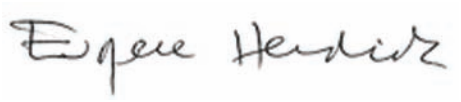
Foreword

Conservation and development of forest genetic resources are fundamental to realising national forest policy goals. Increasing emphasis on biodiversity conservation at ecosystem and genetic levels runs hand in hand with developing the genetic resource of native species, such as ash and birch, and their expanding role in national afforestation programmes. At the same time, capturing and conserving natural adaptation of conifer species, particularly Sitka spruce, which has been used for over a century in commercial forestry in Ireland, is an important goal, and builds on a long-term breeding programme which has resulted in substantial gains in productivity.

Given the long-term nature of tree selection and improvement, and the need for continuity in conservation activities, an overall strategy is needed at national level to guide activities over a period of decades. This publication provides the basis for such a strategy and suggests ways that it should be formalised. In particular, it includes a recommendation that a National Forest Genetic Resources Advisory Group be established to guide the development of the sector. Such an outcome is necessary to provide direction and coherent policy guidance for an area that encompasses regulation, seed and plant production, conservation, research and marketing, all of which are inter-related.

Putting together this report required the dedicated input of a team of the leading national experts in the field of forest genetics. They are to be congratulated for bringing the many strands together into a publication that provides clear recommendations on developing a national strategy to underpin the conservation and development of forest genetic resources in Ireland.



Dr Eugene Hendrick
Director

Brollach

Tá caomhnú agus forbairt na n-acmhainní géiniteacha foraoise ríthábhachtach i mbaint amach spriocanna an pholasaí foraoise náisiúnta. Tá méadú na béime ar chaomhnú bhithéagsúlachta ag leibhéil éiceachórais agus géiniteach ar aon bhonn le forbairt na n-acmhainní géiniteacha de chuid speiceas dúchasacha, ar nós fuinseog agus beith, agus a ról fairsingíoch i gcláir choillteoireachta náisiúnta. Ag an am céanna, tá gabháil agus caomhnú oiriúnú nádúrtha na speiceas cónaiféir go háirithe sprús Sitceach, atá tar éis a bheith in úsáid le breis agus céad bliain i bhforaoiseacht tráchtála in Éireann, mar sprioc tábhachtach, agus forbraíonn sé clár póraithe fadtéarmach le gnóthachain substainteach i dtáirgiúlacht mar thoradh air.

De bharr an nádúr fadtéarmach de chuid roghnú agus feabhsú na gcrann, agus an gá atá le haghaidh leanúnachas i ngníomhaíochtaí caomhnaithe, tá straitéis foriomlán de dhíth ar leibhéal náisiúnta chun gníomhaíochtaí a stiúradh thar tréimhse an ndéaga. Soláthraíonn an foilseachán seo an bonn le haghaidh a leithéid de straitéis agus molann sé bealaí inar cheart é a dhéanamh foirmeálta. Go hairithe, áiríonn sé moladh go mbunófaí Grúpa Comhairleach na nAcmhainní Géiniteacha Foraoise Náisiúnta chun forbairt na hearnála a stiúradh. Tá a leithéid de thoradh riachtanach chun treoir polasaí comhtháite agus stiúradh a sholáthar do limistéar a chuimsíonn rialachán, táirgeadh plandaí agus síl, caomhnú, taighde agus margaíocht, agus baineann siad uile lena chéile.

Nuair a bhí an tuarascáil seo á chur le cheile bhí sé de dhíth go mbeadh ionchur díograiseach foirne ó phríomh-shaineolaithe náisiúnta sa réimse de ghéineolaíocht foraoiseachta. Ní foláir comhghairdeas a dhéanamh leo siúd as ucht an mórán sraith a thabhairt le chéile isteach i bhfoilseachán a sholáthraíonn moltaí soiléire ar straitéis náisiúnta a fhorbairt chun tacaíocht a thabhairt do chaomhnú agus d'fhorbairt na n-acmhainní géiniteacha foraoise in Éirinn.

An Dr Eugene Hendrick
Stiúrthóir

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(b) Controlled pollinations in a spruce breeding programme.
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Executive summary

This report sets out a strategy for the development of Forest Genetic Resources in Ireland for the period 2007 to 2013 under the National Development Plan. It has been formulated as a result of extensive consultation and examination over a 2-year period. It comprises an evaluation of historical developments, together with a review of the current national situation, and concludes by making recommendations for the future development of the sector. It also presents a framework to work towards self sufficiency in reproductive material, and how to develop well adapted, high quality reproductive material to meet current and future needs of the forestry and related sectors, taking into account future climate change scenarios.

Prior to 1989 most work on forest genetic resources was carried out by the Forest and Wildlife Service. Due to reorganisation, work is now spread across several agencies. As a result, a comprehensive national strategy, with a set of focused objectives and goals, together with a programme to support and implement it, is needed to co-ordinate and add value to ongoing work. This is to safeguard and develop genetic resources of native and introduced species.

Funding for existing work in forest genetic resources is being provided through research grants from the EC and COFORD, and through Forest Service development support for nurseries and seed collection. This support needs to be put on a more formal and longer term basis, and extended to fund a comprehensive, national programme in genetic resources, supported by a national tree improvement programme to contribute to the productivity and sustainability of the national forest resource.

The key findings and recommendations are:

- That this report be used by government as the basis of a national strategy in Forest Genetic Resources.
- That a National Forest Genetic Resources Advisory Group (chaired by the Forest Service) comprising relevant stakeholders be established to guide the development of the sector.
- That those organisations currently involved in forest genetic resources build on their strengths and develop their skills and facilities as part of a national programme, with defined objectives and targets under the guidance of the proposed Advisory Group.
- That adequate long term funding be provided by COFORD, the Forest Service, other relevant agencies, and business to support these developments.
- That the national programme is underpinned by dedicated national R&D funding for the period of the National Development Plan, and beyond.
- That the national research priorities identified in this report are agreed, prioritised and implemented by COFORD in collaboration with the Advisory Group.
- That research funding for tree improvement is allocated based on the species priorities outlined in Table 1.
- That existing FGR networks be formalised, and that a structured programme be developed under the guidance of the Advisory Group.

Table 1: Priority species in forest reproductive material programme for the period 2007-2013.

SPECIES	PRIORITY
Ash, alder, birch, oak, Sitka spruce.	High
Beech, cherry, Douglas fir, hybrid larch, Japanese larch, lodgepole pine, Norway spruce, Scots pine, Spanish chestnut and sycamore	Medium
Blackthorn, hazel, holly, Monterey pine, noble fir, rowan, western hemlock, western red cedar, whitebeam, whitethorn and wild apple.	Low

- Forest Service grant schemes to further promote and encourage the use of better adapted, home-collected forest reproductive material and the value and benefits of using improved material.
- That an awareness campaign be prepared and implemented by the Forest Service and COFORD to inform the industry, other interested parties and the wider public, of the importance of forest genetic resources, forest reproductive material legislation, seed collection systems, promoting the benefits of using quality material, showing the negative effects of inferior material and the overall importance of forest reproductive material.
- That a forest genetic resources conservation strategy be developed by the National EUFORGEN[1] Group in co-operation with the Forest Service and the National Parks and Wildlife Service, to include both native and non-native species and create links with the National Biodiversity Action Plan and related pan-European processes. This would complement the work of the Department of Agriculture and Food in the area of conservation of plant genetic resources.
- That infrastructure and capacity building needs in forest genetic resources be continuously reviewed by the Advisory Group in order to create and maintain a critical mass for the sector in the medium to long term.

[1] The European Forest Genetic Resources Programme (EUFORGEN), of which Ireland is a member, is a collaborative mechanism among European countries to promote conservation and sustainable use of forest genetic resources.

1. Background

Forest Genetic Resources (FGR) constitute the genetic resources of both native and introduced forest tree species, either grown or occurring naturally in the country, and encompasses:

1) the genetic material itself,
2) the implementation of the European Communities Council Directive 1999/105/EC on the marketing of forest reproductive material and associated legislation,
3) a national gene conservation programme designed to protect the genetic diversity and uniqueness of both native and important introduced species,
4) a national tree improvement programme to deliver improved quality and productivity in important species that are better adapted to site and climate, and
5) a national R&D programme to fund work on gene conservation and tree improvement.

After centuries of over-exploitation of indigenous forests in Ireland the initial objective of the afforestation programme was to create a resource that would rapidly yield a sustainable supply of timber to reduce dependence on imports. As native tree species generally have long rotation periods, foresters looked to exotic conifers to rapidly replace an over-exploited resource. This was influenced by the relatively poor site types available for afforestation. As a result, there is today a strong reliance on exotic species, and as a consequence FRM has a greater significance in Irish forestry than countries that use a higher proportion of native species, often associated with natural regeneration, and where there is usually a ready supply of FRM *in situ*.

Recent years have also seen a rapid rise in the use of native species such as ash and oak in both commercial afforestation and in the Native Woodland Scheme. These developments also need to be fully catered for in the development of a national strategy for FGR.

Over the years, in the case of conifers, there has been a dependence on importing FRM from the species' natural ranges. Factors such as an initial lack of available seed sources in Ireland, a climate that is not optimal for seed production, and particularly, the low cost of seed imports in relation to home collections militated against the development of self sufficiency in FRM. This situation has slowly been changing with the realisation that there are benefits from securing good home sources. These benefits include:

- less reliance on collections from species' natural ranges, which are often subject to logging with associated supply difficulties;
- use of FRM proven to be well-adapted and productive in the Irish environment;
- the possibility of capturing significant genetic gain through selection, testing and the development of improved material.

It is important that the planting stock used in this country should be genetically suited to the sites on which it is planted. Attempts to rectify the planting of unsuitable or poorly adapted material is expensive in itself, and of course the returns on the crop will be below expectations. it needs to be emphasised that costs associated with utilising the most appropriate FRM are small compared to the cost of forest establishment and management

through the rotation: the cost of using suitable good quality material should not be a deciding point in selecting planting stock.

Past examples of the use of inappropriate FRM are easily found. Large-scale planting of unsuitable provenances of lodgepole pine (*Pinus contorta*), especially inland and Lulu Island sources, resulted in significant losses in roundwood production in Irish forests. More recently, the importation and use of a European continental species, brown-bud ash (*Fraxinus angustifolia*) and its hybrids, instead of common ash (*Fraxinus excelsior*), has resulted in poor quality, uneconomic plantations. This recent introduction has also added the threat of genetic pollution of the native ash gene pool with a much inferior species. These examples clearly illustrate how incorrect seed source selection has resulted in significant financial losses, and the compromising of the genetic integrity of native species.

Having FRM that is well adapted to Irish climatic and edaphic conditions is fundamental to maintaining the sustainability of the forest resource. The development and careful management of FGR is therefore a vital element in ensuring the success of afforestation and regeneration programmes and other relevant State tree planting initiatives. It is also important that large scale tree planting on motorway embankments conforms to the welcome new Ecological Landscape Design guidelines recently published by the National Roads Authority[2].

While FGR initiatives have taken place over the years, there has not been a critical review of the policies or strategies being implemented. The purpose of this paper is to examine the current situation, identify gaps and make recommendations for the further development of FGR, so that the supply and quality of FRM is safeguarded into the future.

[2] NRA. 2006. *A guide to landscape treatments for national road schemes in Ireland*. The National Roads Authority, St Martin's House, Waterloo Road, Dublin 4.

2. Review of current situation

2.1 Policies

2.1.1 FGR policy documents

Growing for the future,[3] published in 1996, outlined policies and a strategic direction for the development of the forestry sector in Ireland. The document addressed FGR, but only at the species level. Policies around the provision of FRM were not provided. Overall, current national policy on FGR is not found in one single document, but comprises a series of policy statements from a number of official documents. These include the EC Directive on the marketing of forest reproductive material (FRM)[4], as well as the Forest Service publications: The *Irish national forest standard*[5], the *Code of best forest practice – Ireland*[6] and the *Forestry schemes manual*[7]. Aspects of FGR are also covered in the Native Woodland Scheme[8], implemented by the Forest Service in partnership with the National Parks and Wildlife Service, which has as its main objective the conservation and enhancement of native woodland biodiversity, including genetic diversity. Aspects are also covered in the Forest Service Biodiversity Plan, which is part of the National Biodiversity Plan[9]. The Forest Service and COFORD are also represented on the Department of Agriculture and Food's advisory committee on genetic resources for food and agriculture.

The National Forest Standard highlights the importance of planting the most ecologically suited species and recognises that as a signatory to the Convention on Plant Genetic Resources and the Convention on Biological Diversity, Ireland is committed to the conservation of plant genetic resources. The standard identifies measures such as:

- implementation of the EC Directive,
- the maintenance of seed stands and seed production areas,
- the production of a national register of seed stands,
- the issuing of certificates of provenance,
- records of superior trees and stands, as well as
- management plans for seed stands.

These measures show that FGR policies are understood and are implemented.

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[3] Department of Agriculture and Food (1996). *Growing for the future: A strategic plan for the development of the forestry sector in Ireland.*

[4] Council Directive 1999/105/EC on the marketing of forest reproductive material. This Directive is transposed into National legislation by Statutory Instrument No. 618 of 2002, the European Communities (Marketing of Forest Reproductive Material) Regulations 2002.

[5] Anon. (2000). *The Irish national forest standard.* Forest Service, Department of Agriculture and Food, Kildare Street, Dublin 2.

[6] Anon. (2000). *Code of best forest practice - Ireland*. Forest Service, Department of Agriculture and Food, Kildare Street, Dublin 2.

[7] Anon. (2003). *Forestry schemes manual*. Government Publications, Dublin.

[8] Anon. (2001). *Native woodland manual*. Forest Service, Department of Agriculture and Food, Kildare Street, Dublin 2.

[9] Anon. (2002). *National biodiversity plan*. Government of Ireland 2002.

[10] MCPFE. 1993. Second Ministerial Conference on the Protection of Forests in Europe Conference Proceedings. 16 -17 June 1993, Helsinki, Finland. Available at the MCPFE Liasion Unit, Warsaw.http://www.mcpfe.org.

The *Code of best forest practice* cites the Ministerial Conference on the Protection of Forests in Europe[10] which concluded that local provenances that are well adapted to local site conditions are to be preferred. It also discusses the perceived threat that foreign material may have on native species. It cites the increased planting of broadleaves, the conservation of surviving native and semi-natural woodlands, and the development of riparian and amenity areas as ways to conserve and enhance the status of native species.

Thus, while not all aspects of FGR are covered in any one document, its importance is highlighted in a number of forest policy documents and measures.

2.1.2 Regulatory mechanisms

Ireland is a signatory to two specific mechanisms that regulate/control trade in forest reproductive material: the EC Council Directive 1999/105/EC referred to previously, and an Organisation for Economic Co-operation and Development (OECD) scheme. These market-based mechanisms and their implementation are part of the FGR policy mix in Ireland. Forest reproductive material, particularly planting stock, is also indirectly regulated under EC Council Directive 2000/29/EC on protective measures against the introduction into the Community of organisms harmful to plants and plant products and against their spread within the Community. Under the Directive plants of certain genera originating in the EU must be accompanied by a Plant Passport to certify freedom from specific pests and diseases. Plants originating in non-EU countries in some cases may be prohibited or are required to be accompanied by a phytosanitary certificate.

EC FRM Directive

In January 2003, EU Directives 66/404/EEC and 71/161/EEC on forest reproductive material were repealed and replaced by a single new directive, Council Directive 1999/105/EC on the marketing of forest reproductive material. The new directive has been transposed into Irish legislation by Statutory Instrument No. 618 of 2002, the European Communities (Marketing of Forest Reproductive Material) Regulations 2002. In Ireland, the Forest Service, Department of Agriculture and Food is the national authority with responsibility for implementation of the Directive.

Under the Directive there are a number of implementing measures:

- Commission Regulation (EC) No. 1597/2002 lays 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.
- Commission Regulation (EC) No. 1598/2002 lays down detailed rules for the application of Council Directive 1999/105/EC as regards provision of mutual administrative assistance by official bodies.
- Commission Regulation (EC) No. 1602/2002 lays down detailed rules for the application of Council Directive 1999/105/EC as regards the ability of a Member State to prohibit marketing of specified forest reproductive material to the end-user.

- Commission Regulation (EC) No 2301/2002 lays down detailed rules for the application of Council Directive 1999/105/EC as regards the definition of small quantities of seed.
- Commission Regulation (EC) No 69/2004 authorises derogations from certain provisions of Council Directive 1999/105/EC in respect of the marketing of forest reproductive material derived from certain basic material
- Commission Decision 2005/942/EC authorises Member Sates to take decisions under Council Directive 1999/105/EC on assurances afforded in respect of forest reproductive material produced in third countries.

Council Directive 1999/105/EC also regulates genetically modified FRM. Currently there is no genetically modified FRM approved for marketing in the EU. Under the Directive genetically modified forest reproductive material shall only be accepted if it is safe for human health and the environment. The material must meet the requirements laid down in governing EU legislation on genetically modified organisms (GMOs), namely Directive 2001/18/EC of the European Parliament and of the Council (as amended), concerning the deliberate release into the environment of GMOs.

The OECD scheme

The OECD scheme[11] was established in 1967 for the control of FRM moving in international trade, and was fully revised in 1974. It is a voluntary scheme between member governments. The objective was to encourage the production and use of seeds, parts of plants and plants that have been collected, transported, processed and distributed, in a manner that ensured their proper identification as to source and parentage.

In 1973, when Ireland joined the then EEC, the OECD scheme was partially superseded by the relevant EEC Directives on the marketing and external quality standards for FRM produced within the EEC, but which covered a limited number of so-called scheduled species. For most other species of importance, Ireland continued where possible to apply the OECD scheme. Under the new EC Directive the OECD scheme is now mainly applied in relation to imports of FRM from non-EU countries.

The current 1974 scheme covers four broad categories of FRM:

1. source identified,
2. selected,
3. untested seed orchards,
4. tested material.

A review of the 1974 scheme has been ongoing since the 1990s in light of the development of new types of material derived from forest tree breeding programmes and to make the scheme compatible with the revised EC Directive. Provisional agreement was reached on a new OECD scheme at the October 2006 biennial meeting of the national designated

[11] Anon. (1974). *OECD Scheme for the Control of Forest Reproductive Material Moving in International Trade.* Organisation for Economic Co-operation and Development, Paris.

authorities (the Forest Service is the authority in Ireland). The new scheme, which is likely to be formally ratified during 2007, will in the short term provide for only two categories of FRM, namely Source Identified and Selected. While both schemes provide a partial framework for national FGR policies, they are limited in their scope and, by their nature, many issues are not addressed, as pointed out further on in this report.

2.1.3 Participation in international FGR networks

Currently Ireland participates in a number of international FGR networks, including European Forest Genetic Resources Programme (EUFORGEN), European Co-operation in Science and Technology (COST) and the British and Irish Hardwoods Improvement Programme (BIHIP). These networks are valuable contact points for Irish FGR scientists and practitioners to meet colleagues working in other countries and facing similar problems. They provide the opportunity to collaborate on common issues at a pan-European level, by developing project proposals and/or pooling the expertise and resources from a number of institutions and countries.

The European Forest Genetic Resources Programme

EUFORGEN is a collaborative initiative among European countries to promote conservation and sustainable use of forest genetic resources. It was established to implement Resolution 2 of the Strasbourg Ministerial Conference on the Protection of Forests in Europe[12]. It operates through a series of networks thay bring together policy makers, managers and scientists to exchange information, discuss needs and develop practical ways to integrate gene conservation into sustainable forest management.

Over the past ten years, EUFORGEN has actively facilitated pan-European collaboration on forest genetic resources and has also contributed to several initiatives in this area. The work of EUFORGEN has helped many European countries to strengthen their national efforts on forest genetic resources and has created a useful platform for pan-European collaboration. EUFORGEN has also contributed to the development of new programmes and policies at the European Union level as well as bilateral projects on forest genetic resources in Europe and other parts of the world.

EUFORGEN continues as an implementation mechanism for the relevant resolutions of the Ministerial Conference on the Protection of Forests in Europe (MCPFE)[13]. Its overall goal is to promote conservation and sustainable use of forest genetic resources in Europe.

Its current objectives are to:

- promote practical implementation of gene conservation and appropriate use of genetic resources as an integral part of sustainable forest management;
- facilitate further development of methods to conserve genetic diversity of European forests;

[12] MCPFE. 2000 General Declarations and Resolutions adopted at the Ministerial Conferences on the Protection of Forests in Europe. Strasbourg 1990 – Helsinki 1993 – Lisbon 1998. Available at the MCPFE Liaison Unit Warsaw. http://www.mcpfe.org.

[13] MCPFE. 2003. Fourth Ministerial Conference on the Protection of Forests in Europe Conference proceedings, 28 – 30 April 2003, Vienna, Austria. Available at the MCPFE Liaison Unit Warsaw. http://www.mcpfe.org.

- collate and disseminate reliable information on forest genetic resources in Europe.

Ireland has participated in EUFORGEN activities since 1998 and has been a member since 1999. A requirement of Phase III of EUFORGEN is that each country nominates a national co-ordinator and a permanent representative on each of the four networks for the duration of the programme. While this is an informal group, members of these networks and the national co-ordinator form the EUFORGEN national committee and meet once a year to discuss forest genetic resources conservation issues at the national and European level. In Ireland, EUFORGEN is funded by the Forest Service.

European Co-operation in Science and Technology

COST[14] is a framework for European Co-operation in Science and Technology and was created in 1971 through an inter-governmental agreement, independently of the framework of the European Community. COST is supported by the EU Seventh Framework Programme, and its scientific secretariat is provided by the European Science Foundation (ESF) through the COST office based in Brussels.

COST's objective is to add value to research investment by co-ordinating, integrating and synthesising results from ongoing nationally-funded research within and between COST member countries. COST funds co-ordination, management, workshops and meetings through its COST Actions which normally are of 4-5 years duration.

Ireland is participating in a number of COST Action programmes including Action E53: *The evaluation of the genetic resources of beech for appropriate use in sustainable forest management*. In 1990, a new initiative on the study of beech seed sources commenced in Grosshansdorf in Germany which resulted in 22 countries across Europe participating in an International Beech Provenance Trial. In Ireland a trial with a number of provenances of European beech was established in Glenmalure in 1998. Another Action addressing FGR is E42: *Growing valuable broadleaved tree species.* Ireland is represented on both Actions.

British and Irish Hardwoods Improvement Programme

Since its inception as the British Hardwoods Improvement Programme[15] in 1991, the British and Irish Hardwoods Improvement Programme has developed as a voluntary association of landowners, research institutions, universities and professional foresters, working to improve the quality and productivity of the main broadleaved species in Britain and Ireland. This is achieved through the implementation of tree improvement programmes.

Originally, ash (*Fraxinus excelsior*) was targeted as the most important species to work on and to date a number of seedling seed orchards have been established. In the mid 1990s, programmes commenced in a further three species including wild cherry (*Prunus avium*), oak (*Quercus robur* and *petraea*) and black walnut (*Juglans nigra*). Later, other species

[14] Birot,Y., Dewar, J., Levlin, J.E., Resch, H., Been, A. and Paschalis, P. (2004). COST co-operation on forests and wood based products: an overview. COST Office, European Science Foundation, 149 Avenue Louise, 1050 Brussels.

[15] Savill, P. (1998). British Hardwoods Improvement Programme. *Quarterly Journal of Forestry* 92: 217-222.

working groups were formed including a birch improvement programme (*Betula pendula* and *pubescens*) as well as Spanish chestnut (*Castanea sativa*). More recently work on sycamore (*Acer pseudoplatanus*) has commenced. At the most recent management committee meeting, an investigation into the establishment of a BIHIP Beech group was initiated.

The working group for each species is normally made up of a landowner as chairman, a researcher as secretary and a number of members with an interest and commitment to work together towards improving the species. One of the main activities of each species group is sourcing funding for ongoing work. Funding comes from a variety of sources. However, the very existence of the programme relies heavily on the goodwill and commitment of many of those involved, as well as the funders.

2.2 Practices

2.2.1 Implementation of FGR policies

The new EC Council Directive 1999/105/EC, which replaced the two previous Council Directives, takes account of the accession of new Member States since 1975, the Internal Market, and scientific advances including the availability of new material. It is also compatible, as far as possible, with the revision of the current OECD scheme for the control of FRM moving in international trade.

The new Directive applies to the production, utilization and marketing of species that are important for a range of forestry purposes including, but not exclusively, the production of wood. It also takes account of the products of breeding programmes and addresses the increasing interest in using material from local sources and gene conservation. It also covers a much wider range of species that are important in Ireland including, ash, alder, birch, sycamore, cherry and lodgepole pine. In addition to the long standing categories Selected and Tested there are two new categories: Qualified and Source Identified. The following is a summary of the four categories:

- ***Source Identified***

  Reproductive material derived from basic material which may be either a seed source or stand located within a single region of provenance.

- ***Selected***

  Reproductive material derived from basic material which shall be a stand located within a single region of provenance, which has been phenotypically selected at the population level.

- ***Qualified***

  Reproductive material derived from basic material which shall be seed orchards, parents of families, clones or clonal mixtures, the components of which have been phenotypically selected at the individual level and which meets certain prescribed requirements.

- ***Tested***

  Reproductive material derived from basic material which shall consist 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 genetic evaluation of the components of the basic material.

Under the Directive the Forest Service is required to maintain a national register of the basic material of the various species approved on its territory, which COFORD compiles on behalf of the Forest Service. The register is better known as the National Catalogue of Seed Stands. The National List of Basic Material is a summary of the national register of basic material presented in a common standardised EU–wide format. Seed and plants may only be marketed if they are derived from basic material identified with a unique reference number in a national register. A key principle of the Directive is that FRM remains clearly identifiable through the entire process from collection to delivery to the end user. Plants are required to be of fair marketable quality by reference to general characteristics, health and appropriate size. There is also a legal requirement for suppliers of FRM throughout the EU to be officially registered. All seed collectors, seed suppliers, nurseries, plant suppliers/brokers in Ireland must therefore be registered with the Forest Service.

All seed collections by registered collectors must be notified in advance, following which a Seed Collection Permit is issued. Seed collections are subject to audit by the Forest Service. Following collection, the collector applies to the Forest Service for a Master Certificate of Provenance for the collection. Where seed or plants are subsequently marketed, the material must be accompanied by a Supplier's Document which incorporates the Master Certificate of Provenance reference number, and the national register reference number for the basic material. Where seed is marketed the supplier, in addition to supplying specified provenance details, must also provide information on seed purity, germination percentage, weight per 1000 seeds and germinable seeds per kg.

For Forest Service grant schemes, plants may only be purchased from registered suppliers. All planting material must be covered by a Supplier's Document in the format of a Provenance Declaration Form. Only specified origins/provenances are grant aided. These origins/provenances are based on research findings in Ireland.

The Provenance Declaration Form is divided into two parts. Part A of the Provenance Declaration Form is completed by the nursery/supplier supplying the plants. The nursery/supplier must declare that the origin/provenance complies with the accepted Forest Service list. Part B of the Provenance Declaration Form is completed by the forestry contractor or applicant applying for the grant. In all cases the contractor/applicant must complete an original signed Part B declaring that the provenance details are correct. The number of trees planted and the applicable plot number on the certified species map must also be specified. These rules provide traceability and assurance to the end user regarding the origin of the seed collection and the suitability of the planting stock. Details of the provenance/origin of planted material also provide an essential forest management record for future reference.

As mentioned, the Directive and the OECD Scheme have provided a framework for FGR policies. These have been implemented by the Forest Service through the Afforestation,

Woodland Improvement and Native Woodland Schemes, where lists of acceptable species and suitable origins/provenances are provided. The main concern, however, is mostly controlling the genetic quality of the FRM to ensure that poor or inappropriate material is not being planted in Irish forests. This means the focus is on material with the lowest level of genetic gain (source identified and selected) and the concern is not directly on developing and encouraging the use of more advanced material from seed orchards and breeding programmes in the categories Qualified and Tested.

2.2.2 Designated seed collection areas

Seed is the most commonly used reproductive material in Irish forestry, with some use by Coillte of cuttings of improved Sitka spruce. Seed comes from three home sources: seed stands, seed production areas and seed orchards. Table 2 shows total area of seed stand by species at the end of 2006.

By far the greatest proportion comes from seed stands that have been selected and registered for their good phenotypic appearance.

Over the years a number of seed production areas and seed orchards have been established which are capable of producing higher genetic quality material than is possible from seed stands. In this document the term seed production areas is used to distinguish such stands where, unlike in a tested seed orchard, scientific testing of the individuals will not be undertaken to remove those that are poorer performing. A list of these areas is presented in Table 3.

Currently, only the Scots pine and some of the lodgepole pine seed orchards are producing commercial quantities of seed, while the hybrid larch orchard is producing seed on an irregular basis. This is because, as pioneer species, pines tend to produce good crops of seed on a regular basis from an early age, which is not the case for most other species. Furthermore, most of the conifer seed orchards date from the 1960s-1980s and need replacement to provide a sustainable seed supply for these species.

2.2.3 Tree improvement programmes

Tree improvement programmes started in the 1950s and early 1960s with the establishment of provenance trials in Sitka spruce and lodgepole pine to determine the most suitable seed origins for Ireland. These programmes were expanded over the years to include many of the major and indeed minor conifer species used in the afforestation programme. In the late 1980s broadleaves became of greater importance and provenance trials were established for most of the major broadleaves, with the exception of alder and sycamore.

Running in parallel with provenance testing were tree breeding programmes for Sitka spruce and lodgepole pine. Programmes of selection, propagation and progeny testing were carried out in these species, as well as the establishment of seed orchards for lodgepole pine. In the 1970s programmes commenced in Monterey pine and in the 1990s on noble fir.

Today, most of the tree improvement activity is in the Sitka spruce programme. A stage has now been reached where tested first generation material is available for multiplication

Table 2: Total area of Irish seed stands by species at end of 2006.

SCIENTIFIC NAME	SPECIES	AREA (HA)
Acer pseudoplatanus	Sycamore	7
Alnus glutinosa	Common alder	110
Betula pubescens	Downy birch	26
Castanea sativa	Spanish chestnut	6
Fagus sylvatica	Beech	80
Fraxinus excelsior	Ash	154
Quercus petraea	Sessile oak	1371
Quercus robur	Pedunculate oak	734
Larix decidua	European larch	8
Larix x eurolepis	Hybrid larch	3
Larix kaempferi	Japanese larch	49
-	Multi-species	36
Picea abies	Norway spruce	438
Picea sitchensis	Sitka spruce	589
Pinus contorta	Lodgepole pine	13
P. nigra	Corsican pine	63
Pinus radiata	Monterey pine	22
Pinus sylvestris	Scots pine	131
Pseudotsuga menziesii	Douglas fir	119
Abies procera	Noble fir	60
Thuja plicata	Western red cedar	9
Taxus baccata	Yew	33
Total		**4061**

Table 3: Seed Production Areas (SPA) and Seed Orchards (SO) currently established in Ireland.

SPECIES (PROVENANCE)	SEED PRODUCTION AREA (SPA) OR SEED ORCHARD (SO)	AREA (HA)	ESTABLISHED IN YEAR(S)	CURRENT STATUS
Lodgepole pine	5 SPA and 3 SO	5.6	1967-1984	SPA not producing, SO producing
Scots pine	2 SO	2.5	1980, 1984	Producing
Monterey pine	1 SPA	1.5	1987	Not yet producing
Hybrid larch	1 SO	0.7	1983	Producing on an irregularly basis
Sitka spruce (Washington)	1 SPA	3.0	2000-2001	Not yet producing
Sitka Spruce (Oregon)	1 SPA	2.0	2002	Not yet producing
Ash	3 SPA and 1 SO	5.0	1989-2006	Not yet producing
Sycamore	1 SO	0.6	2003	Not yet producing
Birch	1 SO	0.16	2003	Not yet producing
Oak	1 SO	1.6	2003	Not yet producing
Alder	1 SPA	0.25	2005	Not yet producing

by vegetative propagation. New laboratory facilities for mass propagation of improved material through somatic embryogenesis have also recently been established by Coillte.

In the early 1990s programmes commenced with some of the broadleaves through the EU ÉCLAIR Programme which supported work on the selection of phenotypically superior oak, ash, sycamore and cherry. More recently, tree improvement work in the commercial broadleaved species has increased due to the establishment of BIHIP.

A summary of the current status of the Irish tree improvement work across a range of conifer and broadleaf species is presented in Table 4. This is the cumulative work of over 50 years of R&D. Results from this work have been central to guiding decisions on seed

Table 4: Current status of tree improvement work with the main Irish tree species.

SPECIES	PROVENANCE TRIALS	PHENOTYPICALLY SELECTED INDIVIDUALS	TESTED FAMILIES	SEED ORCHARDS	VEGETATIVE PROPAGATION
Sitka spruce	+	+	+	+[1]	+
Ash	+	+		+[2]	
Lodgepole pine	+	+	+	+[3]	
Noble fir	+	+			
Monterey pine	+	+	+		+
Oak	+	+			
Western red cedar		+	(+)		+
Scots pine	+		+	+[4]	
Hybrid larch	(+)[5]			+[6]	+
Birch		(+)[7]	(+)[8]		
Norway spruce	+			+[9]	
Douglas fir	+			+[10]	
Japanese larch	+				
Western hemlock	+				
Southern beech	+				
Cherry		+			
Sycamore		+		+[11]	
Alder		+			

+ = in place

(+) = in progress

1 Irish seed orchards (Washington) together with material from seed orchards in the UK (QCI) and Denmark (Washington), although the Danish material has not been tested under Irish climatic conditions.

2 Irish based clonal seed orchard (untested).

3 Irish based LPSC selections (untested) and LP inter-provenance hybrid material to be obtained from UK seed orchards.

4 2 grafted seed orchards, one based on Irish selection (untested) and one based on UK selection (tested).

5 trial of HL seed from a number of European seed orchards.

6 one Irish grafted seed orchards based on UK selection of European larch and Japanese larch.

7 Irish test of Scottish progeny.

8 Irish selected clones currently under test.

9 Norway spruce seed orchards in Denmark.

10 Douglas fir tree seed orchards.

11 Irish selected clones and an untested clonal seed orchard.

purchases and also in establishing superior seed sources for the main species used in Irish forestry. Most of the material (provenances and breeding stock) is held in Coillte property with some broadleaf clones being held at the Teagasc Research Centre in Kinsealy. However, all clone banks should be reviewed, including their location, and maintenance. This needs to be supported by a permanent database to hold all long term records.

A number of organisations also make a major contribution to tree improvement work in Ireland (Table 5) and have developed a high level of expertise in the specific areas that they service.

2.2.4 FGR facilities

The facilities available for the development and management of FGR are reasonably good and are a reflection of the resources allocated to this area in the past. These include:

- **Coillte Tree Breeding Centre** – located at Kilmacurra this is a small specialised nursery dedicated to the production and propagation of improved material. Facilities include glasshouses, indoor seed orchard, clone banks, seed orchards and a bare-root nursery.
- **Plot network of field trials** – A network of field trials has been established on representative site types throughout the Coillte and private estate testing provenance, progeny and clonal material in field conditions.
- **Coillte Micropropagation Laboratory** – based at in Newtownmountkennedy the facility is currently producing 40,000 Sitka spruce emblings per annum using somatic embryogenesis.
- **National Tree Seed Centre** - A state-of-the-art facility, funded by the Forest Service, including cone drying and storage, seed kiln, seed processing and extractory facilities, laboratory and support cold storage and other related facilities in Coillte's Ballintemple Nursery.
- **Teagasc Laboratory and Propagation Facilities** – Long-established micropropagation laboratory and glasshouses/polytunnels at Kinsealy Research Centre with potential for use as pilot indoor seed orchards in alder and birch.

Table 5 : Organisations involved with FGR activities.

ORGANISATION	ACTIVITY
Forest Service	EU FRM Directive and regulation of FGR, OECD scheme, EU Plant Health Directive.
COFORD	Selection and registration of seed stands (on behalf of the Forest Service).
Coillte	Tree improvement programmes (conifers and broadleaves) including provenance trials, progeny testing, development and management of seed stands and seed orchards, Sitka spruce breeding programme, large scale propagation methods.
Teagasc	DNA studies, micropropagation work, joint breeding programme in birch with UCD and an alder improvement programme.
Trinity College Dublin	DNA studies, genetic markers and related areas.
University College Dublin	Participating in a COFORD funded joint project on birch with Teagasc and has participated in other FGR activities in the past but their current research is mainly focused on issues concerning the production of nursery stock.

- **Trinity College Dublin Botany Laboratory** – Modern laboratory facility for botanical and molecular biology studies.
- **University College Dublin Laboratory** – Greenhouse and controlled environment facilities, modern laboratory for botanical and molecular biology studies.
- **Department of Agriculture and Food, Seed Testing Station** – The station is affiliated to the International Seed Testing Association (I.S.T.A.).

(a) Collected acorns drying.
(b) Seed germination tests in a laboratory.
(c) Micro-propagation through somatic embryogenesis.
(d) Pine cones being dried for seed extraction.

3. Requirements

3. 1 Co-ordination of activities

The necessity to have the management of FGR co-ordinated at national level has never been more critical and immediate - having come from a situation where one organisation, the Forest and Wildlife Service, was responsible for all aspects of FGR, there are, as pointed out, a number of agencies and organisations involved. The establishment of a National FGR Advisory Group is necessary to ensure that there is an overall guidance and direction for FGR at national level. This group, chaired by Forest Service and comprising FGR researchers from Coillte, Teagasc, the universities, COFORD, practitioners from nurseries, and other interested parties such as NPWS and Woodlands of Ireland, would provide a forum for informing policy by identifying and agreeing priorities for R&D through adopting national gene conservation strategies, determine seed requirements and monitor plant imports. They would meet twice a year to review and address FGR policy while providing expert guidance. It would also be a useful forum for communicating current information on national and European FGR issues through the institutions into the wider industry.

3.2 Planning future supply

Past experience has shown that anticipating the future requirement for planting is a difficult task and one that is subject to considerable variation. However, an estimate of future demands for planting stock for the next 10 years has been made (Table 6), based on current and future needs, assuming that current species planting trends continue, with Sitka spruce as the main commercial species, but with increased planting of other conifer and broadleaf species. Projected seed requirements are also presented (Table 6).

These figures assume a requirement of 70% conifers and 30% broadleaves. There is, however, an ongoing debate about the current levels of broadleaves being planted. Nationally, the level of broadleaves being planted has risen from 13% in 2000 to 29% today[16] (Table 7). How far this trend will continue is unknown but is likely to be somewhere between the current level of 30% and 50%.

Irrespective of the final breakdown *vis-a-viz* broadleaf/conifer, securing supplies of reproductive material (conifer and broadleaf) from suitable home sources must be a priority. Home sources have proven their worth in the Irish environment and their conservation and management are within national control. In fact, the objective of most European countries is to increase the proportion of genetically improved FRM that is used in planting. This should also be a major objective of Irish forestry, with the aspiration to increase the availability of genetic resources that have been developed in the FRM Directive categories Selected, Qualified and Tested.

To achieve a high degree of self sufficiency, a number of different issues must be addressed:

- continuous identification of suitable sources;

[16] Anon. (2005). *Annual Review and Outlook for Agriculture and Food 2004/2005.* Department of Agriculture and Food, Dublin 2.

Table 6: Estimated annual plant and seed requirement for the period 2007-2016.

Species	Area of seed orchard required (ha)	Annual plant requirement million	Annual estimated seed requirement (kg)
CONIFERS			
Sitka spruce	35	35.0	350
Norway spruce	20	4.5	130
Japanese larch	15	4.5	130
Lodgepole pine	6	4.0	40
Hybrid larch	15	2.0	45
Scots pine	4	1.8	50
Douglas-fir	5	1.0	35
Noble fir	5	0.5	150
Monterey pine	1	0.1	8
Total conifers		53.4	
BROADLEAVES			
Alder	6	5.5	185
Ash	10	4.0	1,600
Oak	10	3.0	35,000
Beech	10	1.5	950
Sycamore	2	0.45	275
Whitethorn	Not applicable	1.3	1,000
Common birch	1	1.0	40
Silver birch	1	0.5	20
Rowan	Not applicable	0.05	35
Holly	Not applicable	0.1	50
Wild cherry	0.5	0.05	25
Hazel	Not applicable	0.06	700
Minor native species	Not applicable	0.08	120
Total broadleaves		18.8	
Total		**72.2**	

Table 7: Total public and private annual afforestation and % broadleaves 1996 - 2004.

YEAR	TOTAL (HA)	PUBLIC (HA)	PRIVATE (HA)	PUBLIC/PRIVATE (%)	% BROADLEAVES
1996	20,982	4,426	16,556	21:79	15.0
1997	11,444	861	10,583	8:92	15.0
1998	12,928	2926	10,002	23:77	15.9
1999	12,667	891	11,776	7:93	15.1
2000	15,696	1465	14,231	9:91	12.9
2001	15,463	316	15,147	2:98	12.4
2002	15,054	319	14,735	2:98	17.4
2003	9,097	128	8,969	1:99	22.8
2004	9,739	122	9,617	1:99	28.8
Total	122,710	11,454	111,616	-	-

- creation of seed production areas/seed orchards;
- establishment of a seed collection infrastructure:
  - seed crop early assessment and reporting system,
  - a cadre of trained seed collectors that can be readily mobilised to avail of seed crops as they become available.

Each of these is now discussed in greater detail.

3.2.1 Future seed sources

Seed stands will continue to be the main source of seed for the foreseeable future. These stands, having grown successfully in Ireland, will provide a basic level of improvement over direct imports at a low cost. The system of selection and registration is working well and should continue as at present.

Production areas for the genetically more advanced material have been established and have been outlined. As pointed out, while long-established pine orchards are producing seed, orchards of other species will take much longer to reach seed-bearing age. A programme of establishing new orchards and replacing existing orchards is now required, to the levels outlined in Table 6. In the interim period, between now and the time that Irish material becomes available, there are opportunities to obtain improved seed from other breeding programmes for a limited number of species. However, these sources should be tested in Ireland against known sources to establish their suitability and establish the level of improvement under Irish conditions.

While the development of seed collection areas (stands, production areas and orchards) is a priority, it is not a guarantee that all our current and future requirements can be met from home sources. Factors such as the time required to make significant progress in tree breeding, the Irish climate which is not conducive to seed production, and periodicity of seed years, all militate against sustained regular production for some species. While seed storage can overcome these difficulties to a certain extent, supplementary imports will be required and here identification of suitable sources is crucial.

In determining the future supply of FRM a number of factors must be taken into account:

- the extent and nature of government grant schemes for planting;
- the demand for the species and specific provenances for particular uses;
- species fecundity in the Irish environment;
- existing seed collections areas, possible improved management to increase production;
- research requirements to service the sector;
- opportunities for co-operation and obtaining improved material from other (overseas) breeding programmes;
- development of technologies to enhance FRM production.

Table 8 synthesises these factors and shows likely sources of conifer and broadleaf reproductive material for the next 10 years.

Table 8: Priority species and projected sources of reproductive material for the period 2007-2013.

Species	Priority	Current Sources	Sources of seed supply 2007-2013[1]			
			Seed Stands	Seed Production Areas	Seed Orchards	Imports
Conifers						
Sitka spruce	High	Seed stands and imports from improvement programmes in Denmark	+++		++	+
Norway spruce	Medium	Imports from improvement programmes in Denmark and Sweden	+		++	+++
Japanese larch		Imports				+++
Hybrid larch		Imports			+	++
Scots pine		Seed Orchards			+++	
Lodgepole pine		Seed orchards and UK imports			+++	+
Douglas fir		Imports from improvement programmes				+++
Western hemlock	Low	Seed stands	+++			
Noble fir		Seed stands and Imports from DK	+			++
Western red cedar		Seed stands	+++			
Monterey pine		Imports				+++
Broadleaves						
Ash	High		+	++		
Oak			++			
Alder			+++			
Birch					+++	
Sycamore	Medium		++			+++
Beech						+++
Cherry						+++
Rowan	Low		+++			
Blackthorn			+++			
Wild Apple			+++			
Hazel			+++			
Holly			+++			

[1] +, ++ and +++ show ascending levels of seed supply

Scots and lodgepole pine readily produce seed at an early age. As result, most of the material required is available from home-grown seed orchards. Seed orchards in other conifer species such as Norway spruce, larches and Douglas fir have, however, produced little viable seed. Seed of these species has therefore been largely imported, and will continue to be so for the foreseeable future. Much of this seed comes from tree breeding programmes and as result improved material, suitable for Irish conditions, is readily available.

3.2.2 Seed stand management and seed production

The management of seed stands is central to the development of a national FGR programme. Prior to their selection and registration, these stands are generally managed for timber production or occasionally as conservation areas. A different management regime is required if seed production is to be enhanced and maximised. This should include thinning in selected stands to open up crowns, to encourage flowering and seed production. Fencing of the large-seeded broadleaf stands may be required to reduce seed predation, along with control of ground vegetation to facilitate seed collection. These operations are standard practice in other countries and should be adopted in Ireland, initially at a pilot scale and depending on success extended into routine operational practice.

Upon registration of a stand, a management plan to enhance seed production should be drawn up. This plan would ensure that there are no conflicts between seed production and the original objectives of the owners. If too many limitations and restrictions are placed on a stand because it is registered as a seed stand, then there will be little if any incentive to register new seed stands, especially in the private sector. Having an agreed plan would also be useful in planning the overall management of the seed stand network and ensure that there are sufficient areas of seed stands available at any one time.

It is important to acknowledge that climate limits good seed years. Some species such as ash are very productive, and typically produce good seed crops every other year, while other species such as oak may produce small seed crops in scattered locations every few years, but produce major crops only once every 5 to 10 or more years. Indeed, the major commercial species, Sitka spruce, produces a good cone crop once every 3 to 7 years. While storage of conifer and some broadleaf seed can overcome supply difficulties, seed of some broadleaved species cannot be stored. It may therefore be impossible to become fully self-sufficient in home-collected seed of these species and imports from suitable sources will be necessary, particularly for oak.

3.2.3 Seed collection logistics

In addition to managing seed stands to facilitate seed crops and their collection it is necessary to have a network of specialised, trained and properly equipped seed collectors who are available to monitor and harvest seed crops across the country at its proper stage of ripening. Without such a group it is not possible to take advantage of good seed crops when they occur. In addition, monitoring of seed crops around the country during the year is necessary to be able to identify where adequate and viable crops occur and to maximise seed collection. Incentives to undertake this work, as well as training, are required to utilise this resource. For specific end uses such as gene conservation, these requirements may need to be funded at the national or EU level.

3.3 Research and development

3.3.1 FGR priorities

The optimal use of the most suitable genetic material, and its further improvement by tree breeding, needs to be supported by a carefully developed, focussed, well resourced, long term programme. This must be designed to identify and select the best material, to develop an efficient system for its production and an operational programme to ensure that the material is utilised to its full potential. Thus, in addition to the overall national strategy, a strategy for the development of an underpinning R&D programme will also be needed.

Early research on FGR was directed towards seeking species and seed origins that were adapted to the climate and soils of Ireland. Tree breeding programmes for lodgepole pine and Sitka spruce were subsequently initiated to further improve these species. Initially, breeding work concentrated on improving the stem form of lodgepole pine. However, as the use of this species declined, resources were redirected towards improving Sitka spruce following the rationale that small improvements in a widely planted species yield better cost-benefits than large improvements in a species that has restricted use. Today, FGR research continues to be mostly directed towards improving Sitka spruce which constitutes over 50% of the overall annual planting programme, including reforestation.

Past research and development programmes on FGR have been developed to a stage where:

- suitable origins for most of our major and minor tree species are known;
- the breeding programme for Sitka spruce is reaching the stage where first generation tested material is available in limited quantities;
- vegetative propagation systems using cuttings and somatic embryogenesis are being developed and are now almost fully operational;
- broadleaf improvement programmes have been started.

Because Sitka spruce is likely to remain our main species, a significant proportion of future investment in FGR research should continue to be directed towards it. While initial improvements in growth and yield have been achieved in the first rotation, potential improvements in wood quality have yet to be realised. Substantial gains in this and other traits are possible through the use of full sibling and clonal varieties.

Broadleaf improvement programmes have been initiated on a project basis with support from the EC Framework Programme and COFORD, but due to the short term nature of much of this funding, ongoing support is not assured and their future direction is uncertain. A clear strategy is required to determine priorities concerning the species and the level of improvement required.

New technologies and techniques such as somatic embryogenesis, flower induction, cryogenic storage, and molecular markers are presenting tree breeders with powerful tools for the development and propagation of improved varieties. The introduction and use of these technologies must be encouraged in Ireland. This can be facilitated through collaborative programmes/projects and with other institutions overseas that have recognised skills in these areas.

Future emphasis therefore needs to be placed on:

- Setting priorities for broadleaf improvement programmes and completing the provenance work on broadleaves;
- Continued development of the Sitka spruce breeding programme by:
  - providing tested material for mass production,
  - developing clonal varieties,
  - demonstrating the potential of family block (full sib) plantings,
  - commencement of second and further generation improvement programmes.
- Advancing vegetative propagation techniques for mass propagation of improved material through:
  - refining techniques for the rooting of cuttings to reduce propagation costs,
  - further development of somatic embryogenesis systems.
- Developing breeding tools such as:
  - flower induction techniques,
  - cryogenic storage systems to retain juvenility of material,
  - early selection and testing methods including marker aided selections to increase efficiency in identifying superior and better adapted individuals and progenies,
  - methods to improve prediction of seed crops,
  - consideration of the effects of climate change on FGR,
  - prioritisation of species in breeding programmes through cost-benefit analysis process.

3.3.2 Collaborative programmes

Many of the species used in Irish forestry are also the subject of tree improvement programmes in other countries. Species that are of particular interest to us, such as Sitka spruce, Norway spruce, hybrid larch, noble fir, Scots pine etc., are to be found in the breeding programmes of countries that have broadly similar climatic and ecological conditions to Ireland. Over the years, seed has been imported from these countries for operational planting and breeding material has periodically been exchanged, mostly with Britain. Given the expense and long term nature of breeding programmes there is, however, merit in exploring the possibility of co-operative programmes that could be beneficial to both parties. The British and Irish Hardwood Improvement Programme is an example of such a co-operative programme.

3.3.3 Expertise

Succession planning

Most of the specialist staff engaged in FGR activities in Ireland are in the later stages of their careers and many are due to retire within the next decade. This will result in a serious knowledge and experience gap unless steps are taken to address this issue. There are currently only three younger persons employed in the entire sector (micro-propagation, birch breeding and seed extractory). While young researchers have been, or are being, employed on EU and COFORD funded projects these are only temporary posts which last for the short duration of the project. Experience and expertise can be lost to FGR when the project terminates. This situation is one of the consequences of not having a comprehensive national programme and the lack of long term dedicated funding in the FGR area.

Specialisation in the universities

FGR is a subject that has not been pursued in any of the Irish universities. While tree improvement is taught as part of undergraduate programmes there are no established research programmes in the subject. An intellectual base is therefore not developed and, as a consequence, FGR does not benefit. Other areas such as forest water relations and biodiversity have clearly benefited from strong research teams in the universities and specialist graduates are available to the industry.

3.3.4 National FGR archives

National record of reproductive material used in Irish forests

A National Record of Reproductive Material (The Seed Register) was established at the start of the State afforestation programme in the early 1920s. This register records all seed lots collected and purchased, including their origins and the nursery to which they were allocated. This is a valuable document for:

- tracing particular seed lots;
- monitoring the genetic background of material imported;
- providing data on the amount, species and location of home-collected and imported seed; and
- analyzing trends in reproductive material used in the planting programmes.

This register is a basic document which should be kept up to date and periodically published. Coillte, since its formation in 1989, has maintained the Seed Register recording all seed imports and home collections that the company has made to date. While this captures the greater proportion of seed imports into Ireland it needs to be expanded to include seed and plant imports by private nurseries and the private forestry sector. This should be developed to a full traceability programme for all FRM by the national authority, the Forest Service.

Pedigree register of breeding material

In addition to the National Record of Reproductive Material, a database of breeding material is required. From the initial selection of material it is important that its genetic background is securely recorded. This becomes more important as time progresses and generations turn over. It is also important to know the location of the material which can be (should be) located in a number of places to lessen the risk of loss. Frequency of use of a particular clone/family in seed orchards, clonal mixes etc. is also vital to ensure that a few genotypes do not dominate.

Breeding material is currently located in half and full sib progeny tests, clonal tests, clone banks, seed orchards, family lines created through somatic embryogenesis, family mixtures for cutting production etc. over three institutions Coillte, Teagasc and UCD. A central pedigree register is essential to manage this material into the future.

Clone banks

The maintenance of breeding material in clone banks and seed orchards is an ongoing cost that is currently being borne mainly by Coillte and to a small extent by Teagasc. This material is a national resource and provision should be made to have it funded as part of the support measures for the forestry schemes.

3.4 Gene conservation – native and non-native sources

The conservation of genetic material is an important part of managing FGR. Genetic variation within each species represents a natural buffer against environmental changes, such as climate change, the occurrence of new pests and diseases and increasing pollution. Genetic variation also represents the building blocks that form the basis for future selection and breeding activities. Maintaining this variation is essential, as there is always a need to have the opportunity to return to the basic material.

In the past, genetic material has been reduced in tandem with the loss of forest cover. Today, genetic resources of native and introduced woody species used for planting purposes in the forests, or in other semi-natural habitats, are not considered as being immediately endangered. However, unless protective measures are taken, the size and constitution of Ireland's forest species, both major and minor, will, as a result of human influence, most likely be affected in the medium to long term in a way that may significantly reduce the buffer function and/or genetic variation.

Silvicultural activities can also have a negative effect on the genetic variation of tree species and consequently on their future stability and potential use. These effects can result in reduced genetic variation, undesirable and widespread mixing of formerly separate populations of the same species or hybridisation between species. Completely uncontrolled hybridisation or mixing of different original genetic units will reduce the future opportunities to choose provenances that are adapted to local conditions and valuable land-races may be lost. A changing climate may also significantly alter the natural distribution area of many forest tree species.

To date few resources have been allocated to gene conservation in Ireland and an urgent requirement is the development of a national conservation strategy for our forest trees which should include both native and non-native species. The strategy should provide for an expansion of the area of seed stands selected for gene conservation purposes which have been established in recent years. The programme must be linked with the National Biodiversity Action Plan and other pan-European plans. To progress this proposal it is suggested that the Danish model be considered. Denmark, which has a forest estate similar to Ireland in terms of size, species and forest history, has developed a comprehensive gene conservation strategy for forest trees[17]. This is an excellent model which could be adapted for Ireland, and the EUFORGEN National Committee should undertake a review of this programme with a view to developing a national strategy for gene conservation for Ireland in the future. The strategy would also complement the Department of Agriculture and Foods's national poilicy on the conservation of plant genetic resources.

(a) Selected Sitka spruce plus tree.
(b) Grafted Sitka spruce ready for establishment of clonal seed orchard.
(c) One parent progeny tests in the field.

[17] Graudal, L., Kjaer, E.D. and Canjer, S. (1995). *A systematic approach to the conservation of genetic resources of trees and shrubs in Denmark*. Forest Ecology and Management 73, pp 117-134.

4. Funding

The development and management of FGR is a long term process and thus requires sustained investment over an extended period. Consequently, tree improvement programmes have been established either by national governments, private industry or co-operative organisations. In developing and funding a programme for FGR, two separate but closely related sectoral programmes can be identified. The first is a research and development programme and the second is an operational programme. In developing a funding programme for FGR there needs to be a clear distinction made between research and an operational programme. The objectives of these programmes are quite different. The former is concerned with identifying and developing suitable reproductive material through provenance studies, breeding programmes etc. while the latter provides the means by which suitable material is produced in commercial quantities and delivered to the commercial forestry sector, i.e. management of seed stands, production and management of seed orchards etc.

4.1 *Historic perspective*

Prior to 1989 active national tree improvement and seed orchard programmes were undertaken and funded by the Forest Service. This situation, however, changed at a national level on the formation of Coillte when funding was mainly directed towards servicing the requirements of the EU Directive on seed stand selection and registration. Coillte has continued to fund some of the improvement and orchard programmes of selected conifer species especially Sitka spruce, largely from its own resources, but staff changes and the lack of external funding inevitably led to the considerably reduced level of activity that exists today. To service this work in 1989 Coillte had ten full time staff working in tree improvement. Today this number has declined to three due to staff changes, staff wastage and reduced external funding.

While the research team in Teagasc also had a capacity in FGR as a result of participation in EU projects, their research focus was mainly in the development of advanced laboratory techniques for determining the genetic background of FGR material and in the improvement in micro-propagation methods. However, in recent years they have also become involved in breeding work on broadleaves.

More recently the Forest Service and COFORD have taken part in the Department of Agriculture and Food's Advisory Committee on Genetic Resources for Food and Agriculture. This provides limited funding for projects related to conservation of genetic resources projects but the level of funding is insufficient to address the issues highlighted here.

Sitka spruce is currently one of the main species supporting the forest products sector in Ireland and it is likely to continue to do so for the foreseeable future. While some Forest Service funding was available for the Sitka spruce tree improvement programme in the early 1990s, since 1995 this work, which is clearly of national importance, has been funded mainly by Coillte own resources. During this time funding from the EU has also declined. Funding has been available from COFORD mainly for specific projects such as the development of the process of somatic embryogenesis which allows for rapid propagation of improved material. Nevertheless, funding to support the breeding programme, including maintenance of gene banks and research facilities as well as the basic breeding and testing work, has declined. There is very limited opportunity for a

co-operatively funded programme between industry and private growers, and hence direct government support of the current national tree improvement programmes is a logical option.

4.2 National considerations

As mentioned above the development and management of FGR is a vital part of the forestry enterprise. While currently there are controls in place to ensure that poor material is not planted, there is little government support for developing and managing our own home sources of superior genetic material. Funding of a national programme sharply decreased on the formation of Coillte and apart from a few EU and COFORD co-funded research projects there has been little investment in the area over the past 10 years. For example, under the 6th Framework Programme of the EC no funding for tree improvement was provided and as a result that source of funding essentially disappeared. For the current 7th Framework Programme, prospects seem somewhat improved but we can not depend on uncertain funding from the EU for such vitally important work . In recent years Coillte, Teagasc and the Universities have been awarded funds for several aspects of work related to the operational and research programmes on FGR. Funds have been provided from the various sources on a project by project basis involving national and international partners. These have played a significant role in establishing and developing areas of expertise and sometimes even international collaborations, and have occasionally resulted in the instigation of important lines of new work which can be further developed. Past funding programmes have typically been of a short term nature with funding for projects which were of 2 to 4 year duration. Occasionally these short term projects have led to follow-on projects again of short duration. Because of the very long time-scale of tree improvement programmes, longer term block grants for selected project areas would be far more satisfactory than the current short term funding of a specific project. This should guarantee satisfactory results and help reduce administrative costs.

An adequately funded, long term programme is required to support a national programme of FRM and tree improvement. Individual programmes funded either by internal sources or the Forest Service, COFORD or the EU have operated independently with little or no national co-ordination. A national policy should help identify priority areas of work and direct resources where they will be best be used. Ireland is one of the few European countries (if not the only one) that does not have a policy or provide ongoing support for the development of FGR. The forest research institutes in, for example, Britain, Denmark, Sweden, France, Germany, Italy, and Spain, have ongoing active FGR programmes that are responsible for developing long term breeding programmes of their main species. Improved material is made available to the state sector through nurseries or forestry companies for propagation and planting.

The estimated investment made by Ireland in FGR activities in 2005 was €750,000. When expressed as a percentage of the total spend on the forestry grants schemes and their support measures in the same year, which amounts to €111 million, it represents approximately 0.67 percent of total forestry expenditure.

5. Recommendations

Strategy

- That this report be used as a basis of a national strategy in Forest Genetic Resources.

National co-ordination

- That a National FGR Advisory Group (chaired by the Forest Service) comprising relevant stakeholders be established to guide the development of the sector.
- That those organisations currently involved in forest genetic resources build on their strengths and develop their skills and facilities as part of a national programme, with defined objectives and targets under the guidance of the proposed Advisory Group.
- That adequate long term funding be provided by government (Forest Service/COFORD) and other relevant agencies, and business to support these developments.

Research and development

- That the national FGR policies are underpinned by a dedicated national R&D programme, funded by Forest Service/COFORD and co-ordinated by the National FGR Advisory Group.
- That national research priorities on FGR are identified, agreed, prioritised and implemented by the various institutions and co-ordinated by the National FGR Advisory Group.
- That resources are allocated to species depending on their importance in the national planting programme.
- That co-operative research networks and programmes continue to be encouraged and facilitated.

Operational plan

- That an adequately resourced FGR operational programme be established under the direction of the National FGR Advisory Group to supply the reproductive material requirements of the state addressing issues such as :
  - Planning and management of seed production areas (seed orchard, seed stands etc.).
  - Seed collection infrastructure.
  - National seed and plant registers for monitoring FGR usage.

Encouraging use of improved material

- Forest Service grant schemes to further promote and encourage the use of better adapted home-collected forest reproductive material and the value and benefits of utilising improved material.
- That an awareness campaign be prepared and implemented by the Forest Service and COFORD to inform the industry, other relevant parties and the wider public, of the importance of forest genetic resources, forest reproductive material legislation, seed collection systems, promoting the benefits of using quality material, showing the negative effects of inferior material and the overall importance of forest reproductive material.

Gene conservation

- That a forest genetic resources conservation strategy be developed by the National EUFORGEN Group in co-operation with the Forest Service and the National Parks and Wildlife Service, to include both native and non-native species and create links with the National Biodiversity Action Plan and other pan-European processes. The strategy would also complement the Department of Agriculture and Food's national policy on the conservation of plant genetic resources.

Capacity building and succession planning

- That infrastructure and capacity building needs in forest genetic resources be continuously reviewed by the Advisory Group in order to create and maintain a critical mass for the sector in the medium to long term.

Appendix

Glossary of terms used in FRM

Clone:	Group of individuals derived originally from a single individual by vegetative propagation for example by cuttings, micropropagation, grafts, layers or divisions.
Edaphic conditions:	Conditions produced or influenced by the soil.
Embling (somatic seedling):	A propagule of somatic embryo origin that has been planted in normal field conditions.
Flower induction:	Stimulation of trees to produce flowers.
Forest tree improvement:	The application of genetic principles to effect improvement of forest trees.
Genetic gain:	The increase in productivity following a change in gene frequency.
Inter-provenance:	A mixture of provenances (origins).
In vitro:	Literally 'in glass'. Used to describe the experimental reproduction of biological processes such as some micro-propagation methods.
Origin:	For an indigenous stand or seed source, the origin is the place in which the trees are growing. For a non-indigenous stand or seed source, the origin is the place from which the seeds or plants were originally introduced.
Phenotype:	The visible characters of a plant and considered the product of the plant's genotype (its genetic make-up) and the effects of the environment in which it is growing.
Progeny:	The offspring of a particular tree or a combination of one female and one male.
Progeny test:	An experiment usually replicated to compare the offspring of different parents, or to compare performance of offspring and parents.
Provenance:	The place in which a group of trees is growing. If seed produced by these trees is harvested and planted, the provenance of the resultant trees is the location of the trees. For example, if seeds are collected from Washington origin Sitka spruce trees growing in Wicklow, the resultant trees are on an Irish provenance. The origin is the place where native trees are growing, or the place from which non-native trees were originally introduced (i.e. Washington in the Sitka spruce example). However, provenance and origin are often considered synonymous terms in the older literature.
Seed orchard:	A plantation of selected clones or families, which is isolated or managed so as to avoid or reduce pollination from outside sources, and managed to produce frequent, abundant and easily harvested crops of seed.
Selection:	A process that results from the differential reproduction of one phenotype as compared with other phenotypes in the same population.

Sibling (Sib): A sexless term meaning brother or sister, individuals belonging to the same family. Half-sibs have one parent in common. Full-sibs have seed and pollen parents in common.

Somatic embryogenesis: The formation and development of embryos from somatic (vegetative) tissues under *in vitro* conditions.

Ash clone bank at Kilmacurra.