THE SECOND REPORT ON THE STATE OF THE WORLD'S FOREST GENETIC RESOURCES

COUNTRY REPORT

IRELAND

This country report was prepared as a contribution to the FAO publication, *The Second Report on the State of the World's Forest Genetic Resources*.

The country reports had two elements: (1) an online questionnaire to gather data and information on forest genetic resources; and (2) a complementary written report. For the written reports, countries were invited to follow the structure of the global report and reporting guidelines adopted by the Commission on Genetic Resources for Food and Agriculture at its Seventeenth Regular Session in 2019.

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An Roinn Talmhaíochta,
Bia agus Mara
Department of Agriculture,
Food and the Marine

THE SECOND REPORT ON THE STATE OF THE WORLD'S FOREST GENETIC RESOURCES

IRELAND – Country Report

Prepared by the Department of Agriculture,
Food and the Marine

agriculture.gov.ie

This country report is prepared as a contribution to the FAO publication, THE SECOND REPORT ON THE STATE OF THE WORLD'S FOREST GENETIC RESOURCES. The content and the structure are in accordance with the recommendations and guidelines given by FAO in the document DRAFT GUIDELINES FOR THE PREPARATION OF COUNTRY REPORTS FOR THE SECOND REPORT ON THE STATE OF THE WORLD'S FOREST GENETIC RESOURCES (2018). These guidelines set out recommendations for the objective, scope and structure of the country reports.

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Ireland

December 2022

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This report was prepared by the Department of Agriculture, Food and the Marine, in consultation with the members of the Council of Forest Research and Development (COFORD) Forest Genetic Resources Working Group.

The Department of Agriculture, Food and the Marine is responsible for ensuring the development of forestry within Ireland in a manner and to a scale that maximises its contribution to national socio-economic well-being on a sustainable basis that is compatible with the protection of the environment.

The COFORD Council is a body appointed by the Minister for Agriculture, Food and the Marine to advise the Minister and its Department on issues related to the development of the forest sector in Ireland. Its membership is appointed by the Minister and comprises stakeholders from across the forestry sector.

Abbreviations and Acronyms

CCF: Continuous Cover Forestry

COFORD: Council of Forest Research and Development

CSO: Central Statistics Office

DAFM: Department of Agriculture, Food and the Marine

DCCAE: Department of Climate Action and Environment

DCCAE: Department of Climate Action and Environment

EUFGIS: European Information System on Forest Genetic Resources

EUFORGEN: European Forest Genetic Resources Programme

FGR: Forest Genetic Resources

FGRT: Forest Genetic Resources Trust

FGRWG: Forest Genetic Resources Working Group

FRM: Forest Reproductive Material

GCU: Gene Conservation Unit

NBG: National Botanic Gardens of Ireland

NHA: National Heritage Areas

NPWS: National Parks and Wildlife Service

OECD: Organisation for Economic Co-operation and Development

SAC: Special Areas of Conservation

SFM: Sustainable Forest Management

Executive summary

The Food and Agriculture Organization of the United Nations (FAO) invited the Irish Government to prepare a second national report on forest genetic resources in connection with the preparation of the second report on the State of the World's Forest Genetic Resources. The national report describes the current state of Irish forest genetic resources and the most important factors that influence the state of conservation and sustainable use of these resources.

Part 1 describes the contributions of forest genetic resources to sustainable development, including the value and importance of FGR. Part 2 describes the state of diversity in forests and includes a summary of the state of forests and other wooded land in Ireland, as well as the state of diversity within and between trees and other woody plant species. Part 3 describes the state of forest genetic resource conservation, including in-situ and ex-situ. Part 4 describes the state of use, development and management of FGR. Part 5 describes the state of capacities and polices and finally Part 6 describes high-level actions for the future development of FGR in Ireland according to the four priority areas of the Global Plan of Acton on FGR.

The report was prepared by the Department of Agriculture, Food and the Marine (DAFM) in consultation with a national advisory group established under the Council of Forest Research and Development (COFORD). Recommendations listed in this report are largely based on a report published by the COFORD Council in 2020 *Sustainable Development and Conservation of Forest Genetic Resources 2020-2030* and is available for download on www.coford.ie.

Part 1 The contribution of forest genetic resources to sustainable development

The objective of this chapter is to present an overview of the economic, environmental, social and cultural conditions as they relate to forests and the forest sector.

1 Value and importance of forest genetic resources

Forest genetic resources are integral to the health and resilience of the forest estate. Quality seed and other reproductive material suited to their environment are the building blocks for forest expansion and are essential to drive the economic, environment, scientific and societal benefits that forests provide. Conservation of the forest genetic resource is important to protect the genetic diversity of our forest resource and thus ensure that they are resilient to the challenges posed by climate change.

Ireland is in the process of developing a new forest strategy to 2030[1] which will be launched in early 2023. The proposed over-riding objective of the new Forest Strategy is that '*between now and 2030 is to radically and urgently expand the national forest estate on both public and private land in a manner that will deliver lasting benefits for climate change, biodiversity, wood production, economic development, employment and quality of life'*. The sustainable use and conservation of forest genetic resources are recognised as being important to realising this ambition.

1.1 Role of forests and the forest sector in the national economy

Forests and forest products play an important role in mitigating climate change by sequestering and storing atmospheric carbon dioxide (CO_2). The national forest estate is an important carbon reservoir, amounting to approximately 312 million tonnes of carbon in 2017[2]. It has been estimated that the level of avoided emissions from fossil-based products through the use of wood-based products is 0.79 tCO_2eq/m^3 at the roundwood stage[3]. This highlights the importance of using wood as a building material to mitigate climate change. The forest sector is relatively young but is increasingly important in the national economy and has a vital role to play in the context of rural development, not only through the diversification of farm income but also through the

[1] DAFM (2022). Irelands forest strategy 2022 -2030 – Draft for public consultation. Department of Agriculture, Food and the Marine. Johnstown Castle Estate, Co. Wexford, Ireland

[2] DAFM (2018). The Third National Forest Inventory 2017, Republic of Ireland, Results. Department of Agriculture Food and the Marine. Johnstown Castle Estate, Co. Wexford, Ireland.

[3] COFORD (2021). Forests and wood products, and their importance in climate change mitigation. A Series of COFORD Statements. COFORD, Dublin, Ireland.

provision of rurally based employment both of which contribute to rural stabilisation and viability.

Irish forests in comparison to the EU as a whole:

- at 11.6%, forest cover in Ireland in 2022 was one of the lowest in the EU 27, where the average forest cover was 38.3%; worldwide forest cover was 31.1%
- in 2020, public forest ownership in Ireland was at 54%, close to the EU average of 53.5%
- annual roundwood harvest was 4.7 million m^3, compared with an EU average of 21.8 million m^3 in the same year (2015 data).
- felling's represented 64.5% of annual increment in 2015, which was slightly below the EU average of 66.8%.
- of all the EU member states, Ireland has had the highest rate of increase in forest expansion as a percentage of total forest cover since 1990.

1.2 Economic, environmental, social, and cultural values of forest genetic resources

Total employment generated by activities in the forest and wood products sector is estimated at 9,000 full-time equivalents and the sector contributes over €2 billion annually to the economy[4]. Ireland continues to support the creation of new forests and provides financial support for forest establishment as well as annual premium payments. There are over 23,500 forest owners in Ireland and in 2021 over €51 million was paid in forest premium payments. This has driven an increase in the availability of timber for harvest. The growing bioeconomy has benefited from a reliable supply of sustainable wood products. For example, the roundwood harvest in 2021 was over 4 million m^3, the highest level since records began, approximately 2 million m^3 of which came from the private sector. Exports of wood products from Ireland are also important to the circular economy; valued at €751 million in 2020[5]. For most forest owners selling timber is the primary source of income from forests and these products will be key in Ireland's transition to a sustainable climate-neutral economy.

Forests have a key role to play in protecting and enhancing Ireland's biodiversity, both in-situ biodiversity (associated with native woodlands and other forest habitats) and ex-situ (concerning wider habitat linkage, and protection of water and aquatic ecosystems). New and existing forests have an important role in water protection particularly in the context of efforts under the Water Framework Directive. The role of forests is set out clearly at a national level in Ireland's current

[4] Forestry Services Ltd., Phillips, H. (2022). Economic activity and employment levels in the Irish forest sector. COFORD, Dublin, Ireland

[5] CSO (2022). Wood and Paper Exports and Imports 2020. Central Statistics Office, Dublin, Ireland.

National Biodiversity Action Plan and Prioritised Action Framework for NATURA 2000 (2021-2027).

As well as the positive attributes of forests, the potential exists for negative impacts on biodiversity that need to be considered and managed. This is evidenced by legacy issues associated with forestry practice in Ireland. For instance, under the Habitats Directive Article 17 reporting framework forestry is listed as both a threat and a pressure affecting just over 30% of Annex I habitats, with a high impact for a little over 15%[6]. Significant challenges also face current forests in delivering favourable results for biodiversity, particularly those in environmentally sensitive areas. For example, a cohort of maturing conifer plantations are located in upland areas and on peatland, on site types that are no longer being afforested. These sites often coincide strongly with protected habitats (e.g., Blanket Bog and Wet Heath Annex I habitats) and species (e.g., Hen Harrier, Freshwater Pearl Mussel) and with sensitive water catchments (namely High-Status Objective Waterbodies). Management needs to consider the knock-on effects of restoring these legacy sites to the pre-forest habitat in terms of deforestation which can impact the carbon sequestration potential of the forest estate.

Practical challenges also exist, for example, in relation to unsustainably high deer populations in many parts of the country, the supply of appropriate reproductive material and the danger of new or existing pests and diseases. For example, the arrival and spread of the Ash Dieback Disease (*Hymenoscyphus fraxineus*) in Ireland over recent years has had a substantial negative effect on semi-natural forests, planted forests and hedgerows. Notwithstanding the above challenges, appropriately sited and managed forests provide many opportunities to protect and enhance biodiversity, including in-situ and ex-situ biodiversity.

Ireland has a magnificent asset in its forest recreation sites and there are opportunities for growth in ecotourism and in unlocking the additional potential of non-wood forest-based products. Since the early 1970s, there has been an active programme of providing recreational facilities in State forests. There are nearly 300 recreational sites, 12 forest parks and over 3,000 km of hiking trails in public owed forests throughout the country. In addition to providing recreational sites such as picnic areas and trails, Coillte (the state forestry company) has an open forest policy that allows free public access to its 440,000 ha estate. The National Parks and Wildlife Service (NPWS) provide access to national parks and nature reserves, and arboreta managed by the Office of Public Works are open to the public. Also, urban forests (public forests established and managed for recreation) owned by County Councils or local communities are quite intensively used being

[6] NPWS (2019). The Status of EU Protected Habitats and Species in Ireland. Volume 2: Habitat Assessments. NPWS, Ireland.

close to population centres. In addition, the Department of Agriculture, Food and the Marine (DAFM) provides grant aid funding to support the development of attractive close-to-home woodland amenities (or 'neighbourwoods') for public use and enjoyment.

1.3 The contributions of forest genetic resources towards relevant Sustainable Development Goals

In 2022 the Shared National Vision for Trees and Forests in Ireland until 2050[7] was launched by the Minister with responsibility for Forestry. It anticipates by 2050 that Ireland's forests will be seen as a key solution to the climate and biodiversity crisis of the 2020s. In support of the Shared National Vision for 2050, a new Forest Strategy[8] has been developed which will be published in early 2023. Ireland's new national forest strategy will stress the multiple functions of forests to the economy and society as well as the essential balance between the ecological, economic, and social functions of forests to ensure these three dimensions of sustainable development receive equal attention. Both the Vision and the Strategy are grounded in the three sustainable development pillars.

- PEOPLE – Involve local communities and landowners in forest expansion at local, regional and national levels and increase people's employment in, engagement with and enjoyment of forests for the benefit of their livelihood, health and wellbeing
- PLANET – Expand and adaptively restore forest ecosystems as a major national sink and store of carbon and a cornerstone of biodiversity, through the rapid and sustainable expansion of climate-resilient and biodiverse forests that support a healthy and high-quality environment.
- PROSPERITY – Continue to grow the economic and employment value of forests as a key enabling element of the new bioeconomy, supporting an innovative, sustainable forestry sector and expanding the use of wood in construction.

1.4 Priorities for enhancing the contribution of forests and the forest genetic resources to sustainable development

The conservation and use of forest genetic resources are important to a forest strategy that envisages a large expansion of the forest estate over the coming decades, and for the regeneration of the existing forest estate. Key priority areas include: Sustainable use of appropriate forest reproductive material in afforestation and reforestation, moving as far as practically possible, to self-sufficiency in forest reproductive material production. Characterisation of the underlying genetic diversity of the main forestry tree species from a production and conservation viewpoint

[7] DAFM (2022). Shared National Vision for Trees and Forests. Department of Agriculture, food and the Marine, Johnstown Castle, Wexford, Ireland.
[8] DAFM (2022). Ireland's Forest Strategy (2022 – 2030) Draft for public consultation. Department of Agriculture, food and the Marine, Johnstown Castle, Wexford, Ireland.

and around native forest restoration. In-situ and ex-situ conservation of genetic diversity in forest tree species.

1.5 Constraints on increasing awareness of the value and importance of forest genetic resources

A national advisory group was established on FGR (COFORD) to provide direction at the national level, principally through producing a renewed indicative strategy for FGR, but also by acting as a forum for organisations involved in the use and conservation of FGR to discuss current issues. This has facilitated a relatively strong awareness of the importance of Forest Genetic Resources. This is evidenced through FGR concerns being included in high-level national policy documents such as the National Climate Action Plan[9] and the Biodiversity Action Plan[10]. Nevertheless, the importance of forest genetic resources needs to be continually highlighted with policymakers, forestry practitioners and the general public. With this in mind, the national advisory group on FGR has called for an awareness programme to be prepared to raise the importance of forest genetic resources, forest reproductive material legislation, seed collection systems, and the promotion of the benefits of the sustainable use of forest reproductive material.

[9] DCCAE (2021). Climate Action Plan 2021. Adelaide Rd. Dublin, Ireland.
[10] NPWS (2017). National Biodiversity Action Plan 2017-2021. NPWS, Arran Quay, Dublin, Ireland.

Part 2 State of diversity in forests and woodlands

2 State of forests

The objective of this chapter is to present an overview of the state of forests in Ireland and briefly explain the trends that have shaped them.

2.1 State of Irish forests and trends in their management

Following the last ice age, Ireland was colonised by vegetation, including trees that migrated from Britain and the European continent. These included species such as ash (*Fraxinus excelsior*), birch (*Betula pubescens* & *Betula pendula*), elm (*Ulmus glabra*), hazel (*Corylus avellana*), rowan (*Sorbus aucuparia*), Scots pine (*Pinus sylvestris*) and willow species (*Salix* spp). Between 7,500 and 5,000 years ago, forest is considered to have covered approximately 80% of the land surface of the country. However, centuries of over-exploitation and clearances for agriculture left the country with a forest cover of just over 1% of the total land area by the beginning of the twentieth century. Few remaining native forests were present, largely limited to fragmented and disconnected islands in a landscape dominated by grassland and peat. Natural or 'ancient' forest is now very rare in Ireland and most stands of trees have been modified and managed to some extent by humans over centuries. Because of this, the term 'semi-natural' is generally used for stands that resemble the potential natural forest cover.

Since the early twentieth-century successive Irish governments, landowners and forestry professionals have achieved significant results in reversing the trend of centuries of deforestation in Ireland. Early afforestation objectives were focused on creating a sustainable supply of timber to reduce dependence on imports, whilst also providing employment in rural areas. As there are a limited number of tree species native to Ireland, and a more limited set again suitable for timber production, foresters looked to non-native species to rapidly replace an over-exploited resource. This was also influenced by the relatively poor site types available for afforestation at the time.

In 1904 the first experimental plots were laid out to test the suitability of various tree species for commercial forests. Based on these trials, and subsequent extensive operational plantings, the merits of introduced tree species, particularly conifers from the Pacific Northwest of America, were first demonstrated. Many of these tree species originate from regions with a climate similar to that in Ireland. Sitka spruce (*Picea sitchensis*), Douglas fir (*Pseudotsuga menziesii*), western red cedar (*Thuja plicata*), western hemlock (*Tsuga heterophylla*) and lodgepole pine (*Pinus contorta*)

are native to Northwest America, while others such as European larch (*Larix decidua*) and Norway spruce (*Picea abies*) originate from the European mainland.

Today, after over a century of afforestation, the forest area has increased to over 808,848 ha, more than 11.6% of the area of Ireland, the highest it's been in over 350 years. Despite this achievement, Ireland's forest cover remains low by European standards. Half the area of forests in Ireland is in public ownership, mainly managed by the state-owned forestry company Coillte, with the remainder owned privately. National Parks and Nature Reserves are also in public ownership and are managed by the National Park and Wildlife Service. Private afforestation increased considerably in the mid-1980s following the introduction of new forestry grant schemes, and today there are over 23,500 private forest owners in the country, mainly farmers. Of the total forest area, over 69% is conifer forest, the remaining is broadleaved or mixed forest. Sitka spruce is the most common tree species, occupying 45% of the total forest area. The most prominent broadleaf species consist of willow and birch, followed by ash, oak and alder.

The forest estate is young with the majority (70%) of Ireland's forests consisting of trees 30 years old or less. In 2017, the total growing stock volume of Irish forests is estimated to be over 116 million m^3, an increase of over 19 million m^3 in 2012. The mean growing stock volume per hectare is now 155 m^3. Above-ground biomass has also been increasing. About 70% of forests are covered by a forest management plan, although these plans are not compulsory, and not officially registered. 56% of forests are under a third-party certification scheme. The state forest agency, Coillte, which accounts for 49.1% of all forests, are certified by both FSC and PEFC, and accounts for most of the certified area.

Plantation forests play an important role. Most forests in Ireland have been established and managed under an even-aged management structure. Trees are planted at a high density and thinned over the lifetime of the forest before the final crop is felled and the timber is used to generate forest products. The forests are then replanted, and the cycle starts again. Large forests are typically managed in smaller sections where trees of different ages are harvested at different times creating a matrix of open spaces, newly planted trees and trees reaching maturity. The Forest Service of the DAFM operates policy and procedures in relation to tree felling which is underpinned by the provisions of the Forestry Act 2014 and includes significant ecological input in the assessment and the legal requirement for felling licences.

While thinning and felling is the main silvicultural system utilised in Ireland. There is growing interest in the use of close to nature systems such as Continuous Cover Forestry (CCF). These systems maintain a continuous forest cover with trees being harvested when they reach the required sizes. Natural regeneration of stands is encouraged through the careful felling and

management of the canopy to allow sufficient light to the forest floor. Over time, the older trees are removed allowing the young trees to reach the upper canopy. By this method, a multi-storied and multi-aged stand structure is formed, and a continuous forest cover is maintained in perpetuity. The number of forests managed under CCF are relatively few, however interest is growing supported by grant aid through the national forestry programme and specialised advice from forest managers, consultants and advisors.

There has also been a steady increase in native forest establishment, supported by grant aid through the national forestry programme. These forests have an overriding ecological focus, for instance emphasis is placed on minimal site disturbance, species selection based on the most appropriate native forest type for the location, the use of planting stock of native origin and long term close to nature management.

Regarding natural forest, as noted above natural forest or 'ancient and long established' forest are very rare in Ireland. Most stands of trees have been modified and managed to some extent by humans over centuries. Some of these have been greatly compromised by the planting of conifers or non-native broadleaves since the early 20th century. Management guidelines have been developed to rehabilitate these forests[11]. For 'ancient and long established' forest these guidelines specify the removal of non-native trees carefully and gradually over time using Continuous Cover Forestry (CCF) systems in order to maintain woodland conditions throughout the process.

[11] Cross, J.R. & Collins, K.D. (2017). Management Guidelines for Ireland's Native Woodlands. Jointly published by the National Parks & Wildlife Service (Department of Arts, Heritage, Regional, Rural & Gaeltacht Affairs) and the Forest Service. Forest Service, Department of Agriculture, Food & the Marine, Kildare Street, Dublin 2, Ireland.

Major forest type	***Main tree species***
Commercial forests are dominated by introduced conifers and can include mix of native/non-native broadleaved species. Semi-natural forests are dominated by broadleaf species such as oak ash, birch and willow.	The main commercial species are coniferous (particularly *Picea sitchensis*). The main species in native woodlands tend to be broadleaves such as, *Quercus petraea, Q. robur, Fraxinus excelsior, Betula pendula* and *B. pubescens.* The main species found in riparian woodlands include *Alnus glutinosa* and *Salix spp*. Notable native conifers include *Pinus Sylvestris*, *Juniperus communis* and *Taxus baccata.*

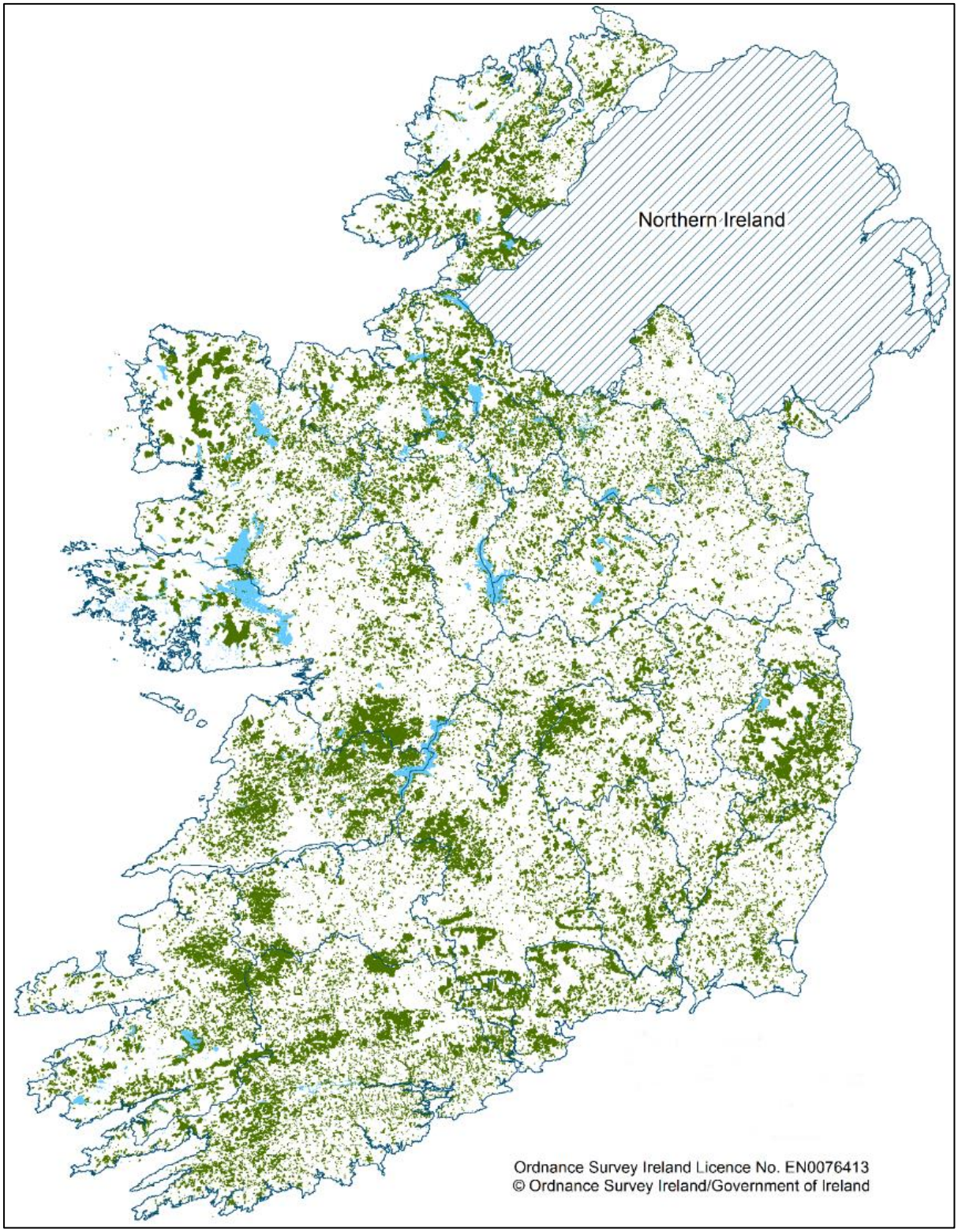

Figure 1 Forest cover in Ireland 2022.

2.2 Drivers of change in the forest sector, and their consequences for forest genetic resources

Key drivers for the forest sector in Ireland include the climate and biodiversity crisis, changes in societal demands of forests, increased focus on delivering biodiverse and multifunctional forests, the needs of the bioeconomy including wood supply and demand, rural development, and skills development within the sector. Of particular relevance to forest genetic resources, include challenges associated with the changing climate, including the impact of pests and diseases and ensuring forests are resilient to these challenges. In particular, the impact on the health and productivity of the forest resources and the need to develop knowledge on the appropriate use of forest reproductive material under a changing climate.

2.3 Challenges and opportunities for forest genetic resources

Forest genetic resources are recognised as being integral to the success of the forest sector in Ireland. Quality seed and other reproductive material suited to their environment are the building blocks for expanding the forest estate and are essential to driving the economic, environment, scientific and societal benefits that forests provide. Conservation of the forest genetic resource is needed to protect the genetic diversity of the forest resource and thus ensure that our forests are more resilient to the challenges posed by climate change. In 2020 a national expert group under the Council of Forest Research and Development (COFORD) published Sustainable Development and Conservation of Forest Genetic Resources 2020-2030. This report provides clear recommendations for developing a national strategy to underpin the development and conservation of forest genetic resources in Ireland. It addresses key challenges faced by the sector, including climate change, and how forest genetic resources can be mobilised to increase the adaptive capacity of our forests. Other core elements include how to ensure the sustainable supply and use of seeds and other reproductive material, and steps required for the genetic conservation of our native naturalised and exotic tree species. The report outlines the roles of those agencies and organisations involved in forest genetic resources and the need to coordinate the effort.

3 State of other wooded lands

The objective of this chapter is to present an overview of the state of other wooded lands and trees outside of forests. Due to limited information on other wooded land, this section is focused primarily on hedgerows.

3.1 State of other wooded lands and trends in their management

Hedgerows are a prominent feature of the landscape in Ireland, most were planted during the 1700s and 1800s when it was obligatory for landowners to erect proper permanent boundaries between their properties. It is estimated that there are approximately a hundred plant species associated with native hedges, including woody species such as *Alnus glutinosa*, *Betula pubescens*, */ pendula, Crataegus monogyna*, *Prunus spinosa*, *Corylus avellana*, *Fraxinus excelsior*, *Quercus robur* and *Quercus petraea* as well as non-native species such as *Acer pseudoplatanus*. A study by Teagasc (the Agriculture and Food Development Authority of Ireland) produced a hedgerow map of Ireland[12], where the national cover of hedgerows, individual trees and non-forest woodland and scrub was estimated at approximately 482,000 ha, or 6.4%, with 80% accuracy. The third National Forest Inventory (2017)[13] estimates national hedgerow and non-forest, other wooded lands, at 347,690 ha, or 4.9% cover. This estimate differs from the Teagasc Irish Hedge Map estimate from 2011, which is most likely due to differing methodologies. In addition, the Teagasc Irish Hedge Map includes areas of non-forest woodland and scrub that under the National Forest Inventory were classified as Forest.

3.2 Trends affecting other wooded land and their management

Hedgerows play a significant role in the natural landscape. Not only do hedgerows contribute to the sequestration of carbon from the atmosphere but they are also vital as a habitat for wildlife, a resource for biodiversity and a unique heritage feature. Hedges can be the most abundant and frequently occurring wildlife habitat on Irish farms. However, in many cases are classed as low quality primarily because of impoverished ground flora, with very low species diversity in the ground flora and within the hedgerow woody species. Hedgerows are impacted by clearance for agriculture and land use change.

3.3 Challenges and opportunities for forest genetic resources in other wooded lands

As noted above a key challenge to hedgerows is an intensification of agricultural practices and a change of land-use. In addition, the severe impact of earlier introduced tree diseases such as

[12] The Irish Hedge Map – Version 1.0. Teagasc, 2011

[13] DAFM (2018). National Forest Inventory Main Findings 2017. Department of Agriculture, Food and the Marine, Johnstown Castle Estate, Wexford, Ireland.

Dutch elm disease (*Ophiostoma novo-ulmi*) as well as the more recent introduction of ash dieback disease (*Hymenoscyphus fraxineus*) are evidence of the serious threat from pests and disease. Ash dieback disease will likely have a major impact on hedgerows in Ireland in the coming years.

The value of hedgerows and trees outside of forests is reflected in recently introduced agri-environmental schemes funded under the Common Agricultural Policy (CAP) which have resulted in the establishment of new hedgerows and trees outside of the forest. These schemes provide opportunities to rejuvenate existing hedgerows and establish new ones. Since their introduction in 1994 a total of 6,605 kilometres of new hedgerows and more than 3.7 million trees have been established on non-forest land[14].

4 State of diversity between trees

The chapter provides an overview of the current state of genetic diversity in tree and other wooded plant species that are considered as "forest genetic resources" and managed or utilised in the forestry context.

4.1 Species considered as forest genetic resource and manged or utilised in a forestry context

Ireland is home to a range of native, non-native and naturalised tree species. There are approximately 36 native tree species (including some shrub species)[15]. The number of native tree species managed or utilised in a forestry context is much smaller, mainly *Betula* spp*., Quercus* spp. *and Pinus sylvestris* (Table 1). Traditionally non-native tree species have played an important role in the forestry context. Sitka spruce (*Picea sitchensis*) is the most common tree species, occupying 44.6% of the total forest area. Over one-quarter of the forest estate contains broadleaves. One-third (33.6%) of the broadleaves are 'Other broadleaf species' (both long-living and short-living), of which over half are *Salix* spp[16]. The next largest broadleaf species group are *Betula* spp. (24.4%), followed by *Fraxinus excelsior* (13.1%) and *Quercus* spp. (9.2%). Conifers occupy 479,530 ha while broadleaved species cover 193,580 ha (Table 1)[17].

[14] DAFM (2022). Forest statistics 2022. Department of Agriculture, food and the Marine. Johnstown Castle Estate, Wexford, Ireland.
[15] Parnell. J , Curtis, T & Cullen, E (2012). Webbs An Irish Flora. (8 ed.). Cork: Cork University Press.
[16] The species group composition of long living broadleaves are as follows: field maple, maple, horse chestnut, strawberry tree, hornbeam, sweet chestnut, holly, nothofagus spp., white poplar, black poplar, Turkey oak, red oak, whitebeam, small-leaved lime, large-leaved lime, wych elm. The species group composition of short living broadleaves are as follows: crab apple, aspen, cherry, blackthorn, goat willow, other willows, mountain ash, and hazel.
[17] DAFM (2017). National Forest Inventory. Department of Agriculture, Food and the Marine. Johnstown Castle Estate, Wexford, Ireland.

Table 1 Forest species currently used and managed in Ireland (not in order of priority).

Species	**Native (N) or Exotic (E)**	**Management**
Alder (*Alnus glutinosa*)	N	Plantation/natural
Ash (*Fraxinus excelsior*)	N	Plantation/natural
Beech (*Fagus sylvatica*)	E	Plantation
Birch (*Betula pubescens/pendula*)	N	Plantation/natural
Pedunculate oak (*Quercus robur*)	N	Plantation/natural
Sessile oak (*Quercus petraea*)	N	Plantation/natural
Silver birch (*Betula pendula*)	N	Plantation/natural
Sycamore (*Acer pseudoplatanus*)	N	Plantation
Willow spp (*Salix spp*)	N	Natural
Other broadleaves	N/E	Plantation/natural
Douglas fir (*Pseudotsuga menziesii*)	E	Plantation
Larches (*Larix* spp)[18]	E	Plantation
Lodgepole pine (*Pinus contorta*)	E	Plantation
True firs (*Abies spp*)[19]	E	Plantation
Norway spruce (*Picea abies*)	E	Plantation
Scots pine (*Pinus sylvestris*)	N	Plantation / natural
Sitka spruce (*Picea sitchensis*)	E	Plantation
Other conifers	E	Plantation

[18] *Larix decidua, Larix x eurolepis, Larix kaempferi*
[19] *Abies grandis, Abies amabilis, Abies procera*

4.2 Drivers for change in the number of species and threats to species

Strengthening resilience and reducing vulnerability to climate change are key drivers. Ireland operates an approved list of species, provenance and origins for grant aid. This list has been developed based on trials carried out over many decades. However, changing environmental conditions associated with climate change are creating uncertainties about the future adaptability of forest tree species. An understanding of the adaptive potential of the range of tree species used in Irish forestry is needed to assess if the species, provenances and origins currently utilised in a forestry context need to be adjusted or expanded.

Ireland's forest health status overall is relatively good, largely as a consequence of our island status, the relative newness of the forest estate and the implementation of import controls. Ireland does not currently have the range of forest pests and diseases that are endemic on the European continent and further afield. However, serious threats from pests and diseases are on the increase due to globalisation and trade and the impacts of climate change. In recent years there have been a number of disease outbreaks in trees and forests, most notably ash dieback disease caused by the fungus *Hymenoscyphus fraxineus* and *Phytophthora ramorum*, a fungus-like organism, that can damage and kill plants and trees it infects, principally *Larix* spp. Both pathogens are relatively newly described species, illustrating the threat posed by new and emerging pests and diseases. The impact of ash dieback disease has had a substantial negative impact. It was first detected in Ireland in 2012. The disease is now present throughout the island of Ireland.

No tree species or woody forest species have been identified as being threatened or placed on a red list in Ireland[20]. Of the native species, only black poplar (*Populus nigra*) may be under some threat, which has been shown to have a restricted genetic diversity in Ireland[21]. Several species have restricted distributions and limited populations, such as tea-leaved willow (*Salix phylicifolia*), buckthorn (*Rhamnus cathartica*) and alder buckthorn (*Frangula alnus*). Other species are important components of EU Annex habitats, which are protected under the EU Habitats Directive (for example, oak species and yew).

There is a growing interest in agroforestry, including silvopastoral and silvolarable systems. It is incentivised through the national forestry programme. Agroforestry establishment is by artificial means, acceptable species typically include *Quercus*, *Acer pseudoplatanus* and *Prunus avium*, and

[20] Wyse Jackson, M., FitzPatrick, Ú., Cole, E., Jebb, M., McFerran, D., Sheehy Skeffington, M. & Wright, M. (2016) Ireland Red List No. 10: Vascular Plants. National Parks and Wildlife Service, Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs, Dublin, Ireland.

[21] Keary, K., A'Hara, S., Whitaker, H. & Cottrell, J. (2005). Assessment of genetic variation in black poplar in Ireland using microsatellites. Irish Forestry, 62, 6 - 18.

include a proportion of fruit and nut trees. Other species can also be considered on a site-by-site basis.

5 State of diversity within trees and other woody plants species

The objective of this chapter is to provide an overview of the current state of genetic diversity in tree and other wooded plant species that are considered as "forest genetic resources" and managed or utilised in the forestry context.

State of diversity within trees

Evidence suggests that most populations in semi-natural woodlands in Ireland contain high levels of genetic diversity. Recent work by the National Botanic Gardens of Ireland has investigated the genetic diversity of a number of important native species, including, ash, birch, oak and Scots pine. Using a variety of DNA markers (restriction fragment analysis, SSRs, and SNPs) native tree populations in Ireland were genotyped and compared with other European studies. It was found that Irish populations represent a subset of the genetic diversity in Europe, as is to be expected for populations at the marginal range of a species distribution. The data was also used to infer genetic provenance of Irish populations, for example, in birch it was identified that populations originated from post-glacial refugia in the Iberian Peninsula and a second eastern refugium in Europe[22]. It was also identified that Irish populations of birch could potentially have unique postglacial genotypes, highlighting the importance of genetic characterisation in conserving forest genetic resources. For ash, like Britain, Ireland is dominated by one main haplotype which originates from an Iberian glacial refugium[23]. For Scots pine, (once thought to have disappeared from the Irish landscape), data from refugium populations confirm a close genetic link with Scottish populations, although a greater resolution was not possible to distinguish Irish from Scottish populations. For oak, data also indicates Ireland contains a subset of the variation found in Europe.

For our non-native species in plantation forests the within species genetic diversity is less well understood. However, seed acquisitions have been made over a considerable period and from many different sources, therefore there is an expectation of a wide range of genetic variation within Irish populations. A recent research project featuring researchers from the Teagasc (Irelands agriculture and food research authority), together with Irish Universities and the National Botanic Gardens, aims to document the genetics of Sitka spruce forests in Ireland

[22]Belton, S.; Cubry, P.; Fox, E.; Kelleher, C.T. Novel Post-Glacial Haplotype Evolution in Birch (2021). A Case for Conserving Local Adaptation. Forests,12, 1246. https://doi.org/10.3390/f12091246

[23] Belton, S., Fox, E. & Kelleher, C.T. (2022). Characterising the molecular diversity of ash (Fraxinus excelsior L.) at its western marginal range in Europe — phylogeographic insights and implications for conservation in Ireland. Tree Genetics & Genomes 18, 36 . https://doi.org/10.1007/s11295-022-01567-6

assessing genetic diversity and if genomic selection can be used to accelerate tree-breeding efforts[24].

5.1 Current and emerging technology for assessing monitoring genetic diversity

Work is ongoing by Irish researchers on developing integrated techniques of molecular biology, DNA fingerprinting, bioinformatics, and plant pathology to understand the genetic relationship within and among the populations of non-native, native and naturalised species such as alder, birch, oak, Scots pine, Sitka spruce and sycamore, as well as the resilience for ash and alder to existing diseases under natural and controlled environmental conditions in Ireland. Genetic profiling of seed orchards is also being used to maximise their utilisation and complement the efforts in the establishment of new seed orchards. The work will also indicate whether the existing seed orchards are genetically diverse enough to continue our reliance on them or if there is a need for increasing diversity by adding genetically diverse genotypes that are suitable to Irish climatic conditions[25].

Capacity-building and research needs to increase the availability on information on the genetic diversity

In terms of research needs, for autochthonous populations, the genetic component of forest trees needs to be studied in greater details to assess adaptive potential.

Ireland has a relatively high demand of forest reproductive material to meet its needs for afforestation and reforestation, appropriate use of reproductive material depends on knowledge on the diversity of the basic material. See section 8.4 on research needs as they relate to use of FGR.

There is need to develop and retain skilled researchers in the field, this is a challenge across the FGR area and forest research more generally. In a similar way too many areas of forest research in Ireland, there is a reliance on project-based funding, which creates challenges regarding continuity, as well as funding of operational research requirements, including monitoring of field trials, maintenance of gene banks etc.

[24] Teagasc (2020). Genetic characterisation of Sitka spruce in Ireland. TResearch, Spring 2020 15(1).
[25] Teagasc (2022). BroadGen - Studying the genetic diversity and resilience of commercially important broadleaved tree species in Ireland. Teagasc, Oak Park, Carlow.

Part 3 State of forest genetic resource conservation

6 *In-situ* conservation of forest genetic resources

The objective of this chapter is to provide an overview of the current state of *in-situ* conservation of forest genetic resources, and the needs, challenges and opportunities for improving it in Ireland.

6.1 Approaches used for *in-situ* conservation

Ireland is home to a range of native, non-native and naturalised tree species that have adapted in various ways to their environments. Some of this genetic diversity has evolved naturally over generations as species have adapted at a fine scale to local conditions. In other cases, it is the product of deliberate efforts over many years to develop varieties that are productive in Irish conditions.

For native species *in-situ* conservation is maintained through woodlands protected for conservation in National Parks and Nature Reserves. Some 2,628 ha are protected within 32 nature reserves, 2,854 ha within national parks. A further 6,468 ha are designated as Special Areas of Conservation (SACs) under EU legislation and 23,784 ha are proposed as National Heritage Areas (NHAs) under national legislation. There are also several government initiatives to encourage conservation of native broadleaf woodland, for example the Native Woodland Conservation Scheme. This scheme is aimed at encouraging at the proactive protection and expansion of Ireland's native woodland resource and associated biodiversity, using appropriate close-to-nature silviculture. Its main objective the conservation and enhancement of native woodland biodiversity, including genetic diversity.

A network of gene conservation units (GCU) of native species has also been established using a dynamic or near nature approach. High level actions for GCU establishment, management and monitoring are listed in Table 2. To date, Ireland has seventeen GCUs established, these include populations of oak, birch, mountain ash, alder, ash, and Scots pine. These are listed on the European Information System on Forest Genetic Resource (EUFGIS), an initiative by European countries under the European Forest Genetic Resources programme (EUFORGEN).

Table 2 Actions for gene conservation of Forest Genetic Resources (FGR) and its implementation.

1	Set gene conservation objectives and targets
2	Select species based on objectives.
3	Biological assessment: assessment of bioclimatic envelopes and level of threat.
4	Genetic assessment: Where available utilise genetic data to categorise populations.
5	Genetic characterisation: Genetically characterise populations, where data are needed.
6	Select populations: Utilise criteria presented in this 5.1.3 to select suitable populations.
7	Assess populations: Assess the status of the populations being selected to provide a baseline for monitoring and assess threats.
8	Create management plans for conservation units.
9	Set monitoring protocols & decide the frequency of monitoring and the level of monitoring needed.

6.2 Organisation of in-situ conservation efforts at national level

There are several organisations involved in forest genetic resource conservation in Ireland, each with their own particular focus (Section 11, Table 8). A national advisory group is in place to co-ordinate actions on FGR Conservation[26] and provide direction at the national level, this group has adopted a strategy for in-situ conservation and is overseeing its implementation.

6.3 Needs, challenges and opportunities

In 2020 a Gene Conservation Strategy for native species was adopted by the COFORD Council[27]which set out a list of actions for the dynamic conservation of key species. Recommendations made have been partially adopted and gene conservation strategy for native species adopted. There is a however need to improve the network and include additional species, particularly minor species. In addition, there is a need to further develop the strategy to incorporate the dynamic conservation of important non-native and naturalised tree species.

6.4 Priorities for capacity building and research

There is need to develop and retain skilled researchers in the field, this is a challenge across the FGR area. Priorities for capacity building include the continued implementation of the native tree

[27] COFORD (2020). Sustainable development and conservation of forest genetic resource 2020-2030. COFORD, Kildare St. Dublin 2.

gene conservation strategy as noted above, and the development of a greater understanding of the genetic diversity of tree populations in Ireland.

7 *Ex-situ* conservation of forest genetic resources

The objective of this chapter is to present an overview of the current state of ex-situ conservation of forest genetic resources, and the needs, challenges and opportunities for improving ex-situ conservation in Ireland.

7.1 Approaches used for ex-situ conservation

Ex-situ conservation of forest genetic resources plays a complementary role to in-situ conservation by safeguarding genetic diversity away from the risks it encounters in the landscape and making it easily accessible for research. Ireland has an active programme of ex-situ conservation of forest tree species as well as information on species and materials in germplasm collections. Ex-situ conservation is undertaken by several state and semi-state agencies, including DAFM, Teagasc, the National Botanic Gardens, Coillte, the NPWS and the Forest Genetic Resources Trust. Data on ex-situ conservation areas are maintained by the host organisations and by DAFM at a national level. A proportion of forest genetic resources has been captured through tree improvement programmes and their associated provenance and progeny trials. Further material exists as living collections in botanic gardens and arboreta. Protection of forest genetic diversity in gene banks and collections will ensure that these genetic resources of various tree species are conserved should they be needed for future use or breeding programmes. These areas also serve as demonstration plots which are a very useful way of illustrating the importance of FGR to forestry practitioners. For example, the research plots in the John F Kennedy Arboretum, New Ross, Co. Wexford were setup originally as demonstrations of species and provenance performance and now also serve as important conserves of genetic diversity. For example, an IUFRO collection of Sitka spruce established between 1968 and 1970, consists of 81 provenances spanning the entirety of its native range and is being used by breeders to gain a greater understanding of the genetic diversity of Sitka spruce populations in Ireland[28].

7.2 Needs, challenges and opportunities for ex-situ conservation

Ex-situ populations of important non-native species are currently maintained either dynamically through a network of seed stands or in gene banks and seed orchards. The key challenge in this space has been the reduction of long-term research activities in tree breeding and the absence of an overarching national tree improvement programme. Currently there are no specialist

[28] Byrne, T., Farrelly, N., Kelleher, C., Hodkinson, T. R., Byrne, S. L., & Barth, S. (2022). Genetic Diversity and Structure of a Diverse Population of Picea sitchensis Using Genotyping-by-Sequencing. Forests, 13(9), 1511.

personnel working exclusively in FGR in any Irish third level institution, but there are several active projects in FGR. There is need to develop and retain skilled researchers in the field, this is a challenge across the FGR area.

Part 4 State of use, development and management of forest genetic resources

8 The state of use of forest genetic resources

The objective of this chapter is to provide an overview of the state of forest genetic resources use, and the needs, challenges and opportunities in this area in your country.

8.1 Trends in the production & demand of forest reproductive material

In Ireland, artificial planting is the predominant method of forest establishment, most of it on former agricultural land. Regeneration is almost always by planting. The country is classified as one region of provenance. Forest reproductive material is identified and utilised according to the regulations as prescribed by EU Council Directive 1999/105/EC. Seed is the most used reproductive material apart from a small amount of cuttings material from the Sitka spruce improvement programme. Seed comes from two home sources: seed stands and seed orchards, the greater proportion of which comes from seed stands. The seed stands selection and registration programme is carried out by DAFM; it is an ongoing programme to fulfil the requirements of the EU Directive 1999/105/EC (Table 3, 4). Following a legislative amendment in 2021 all EU national registers will be updated and accessible via the new EU FORMATIS database system. This system also caters for all tree species of national importance, including those of interest for FGR purposes, apart from the species scheduled and regulated under the Directive.

Table 3 Seed stands registered by species and Category on the National Register of Approved Basic Material (DAFM, 2020[29]).

Species	*'Source Identified'*		*'Selected'*	Total	
	No. of Stands				
Noble fir	-		4	4	
Sycamore	-		8	8	
Italian alder	-		1	1	
Common alder	10		2	12	
Downy birch	5		8	13	
Sweet (Spanish) chestnut	-		3	3	

[29] DAFM, (2022) Forest statistics 2022. Department of Agriculture, food and the Marine. Johnstown Castle Estate, Wexford, Ireland.

Species	*'Source Identified'*	*'Selected'*	Total
Lawson cypress	-	1	1
Japanese cedar	2	-	2
Monterey cypress	-	1	1
Beech	-	19	19
Ash	4	4	8
European larch		3	3
Japanese larch	-	7	7
Mixed Species Stands	3	-	3
Norway spruce	-	24	24
Sitka spruce	-	49	49
Lodgepole pine	-	10	10
Corsican pine	-	2	2
Monterey pine	-	8	8
Scots pine	4	14	18
Douglas-fir	-	21	21
Sessile oak	24	26	50
Pedunculate oak	20	30	50
Coast redwood	1	-	1
Yew	4	-	4
Western red cedar	-	6	6
Western hemlock	-	5	5

Table 4 Number of seed orchards registered on the National Register of Approved Basic Material (DAFM, 2022[30]).

Species	*'Qualified'*	*'Tested'*
	No. of Seed Orchards	
Sycamore	2	-
Alder	3	-
Downy birch	2	-
Spanish (sweet) chestnut	1	-
Ash[31]	4	-
Hybrid larch[32]	1	-
Sitka spruce	1	2
Lodgepole pine	2	-
Scots pine	4	-
Wild cherry	1	-

30 DAFM (2022). Forest statistics 2022. Department of Agriculture, food and the Marine. Johnstown Castle Estate, Wexford, Ireland.

32 *Larix x eurolepis*.

Table 5 Main broadleaf species sown (kgs seed with an approximation of the number of plants (‘000) in forest nurseries (2015-2019).

Species	2015		2016		2017		2018		2019	
	Kg	Plants (‘000)	Kg	Plants (‘000)	Kg	Plants (‘000)	Kg	Plants (‘000)	Kg	Plants (‘000)
Alder	128	3,840	117	3,510	113	3,387	92	2,754	118	3,525
Ash	2	4	-	-	-	-	-	-	-	-
Beech	936	749	466	373	1,041	832	683	546	870	696
Common birch	30	1,337	49	2,192	54	2,439	52	2,343	60	2,700
Silver birch	11	338	10	300	7	204	8	227	8	225
Cherry	25	20	13	11	1	1	1	1	20	16
Pedunculate oak	6,840	684	24,635	2,464	20,663	2,066	25,302	2,530	15,406	1,541
Red oak	124	10	98	8	100	8	100	8	100	8
Sessile oak	659	53	190	15	5,363	429	4,269	342	1,400	112
Sycamore	233	326	100	141	153	214	15	21	95	133

Table 6 Main conifer species (kgs seed with the approximation of the number of plants (‘000)) in forest nurseries (2015-2019)

Species	2015		2016		2017		2018		2019	
	Kg	Plants (000)	Kg	Plants (000)	Kg	Plants (000)	Kg	Plants (000)	Kg	Plants (000)
Douglas-fir	26	650	18	450	20	500	19	475	30	750
Larch, European	5	256	-	-	0.3	16	0.3	15	0.4	18
Larch, hybrid	0.2	9	0.2	9	0.3	13	0.3	13	0.3	13
Lodgepole pine	32	2,868	17	1,530	23	2,030	22	1,983	25	2,247
Norway spruce	84	3,360	84	3,340	101	4,024	91	3,643	104	4,154
Scots pine	30	1,212	32	1,278	67	2,685	80	3,197	46	1,834
Sitka spruce	202	20,249	326	32,585	280	27,986	247	24,680	380	37,950
Western red cedar	-	-	1	38	1	37	1	44	0	28

8.2 Certification of Forest Reproductive Material

The Department of Agriculture, Food and the Marine (DAFM) is the implementing agency in Ireland of EU Council Directive 1999/105/EC on the marketing of forest reproductive material, commonly called the FRM Directive. This Directive is transposed into Irish legislation by Statutory Instrument No. 618/2002, the European Communities (Marketing of Forest Reproductive Material) Regulations 2002. Ireland is also a member of the Organisation for Economic Co-operation and Development (OECD) scheme for the certification of forest reproductive material moving in international trade, otherwise known as the 'Forest Seed and Plant Scheme'.

The main objective of the FRM Directive is to ensure that forest reproductive material, which is marketed, is from approved suitable sources and is clearly labelled and identified throughout the entire process from tree seed collection to processing, storage, forest nursery production and delivery to the final forest user. The Directive provides a set of criteria that describes the types of material which can be legally marketed throughout the EU. It provides a framework for describing the geographic origin and the phenotypic quality which the seed sources provide. Under the Directive, forest reproductive material is categorised based on its level of genetic quality and the degree of selection and testing that has been applied. It is a mechanism to provide information to growers on the genetic quality of reproductive material that they purchase for planting in their forests.

The OECD Forest Seed and Plant Scheme was established in 1967 for the control of forest reproductive material moving in international trade. The scheme was fully revised in 1974. A second full revision was made in 2007. The objective of the scheme is 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. The scheme enables participating countries to recognise equivalence in their respective FRM production systems thus facilitating trade. In 1973, when Ireland joined the then EEC, the OECD scheme was partially superseded by the relevant EEC Directives and later Council Directive 1999/105 on the marketing and external quality standards for forest reproductive material, produced within the EEC, but covering a limited number of species (scheduled species). For all other species, the OECD scheme still applied. With the expansion of the EU to 27 Member States the OECD scheme in Ireland has in recent years mainly applied to imports of FRM from non-EU countries. Post the UK leaving the EU, the OECD scheme has become more important as it is the regulatory FRM certification system for exports and imports of FRM to UK (Great Britain), who are also members of the OECD scheme. The scheme is now largely equivalent to the EU FRM Directive and similarly covers four broad categories of FRM, ''Source Identified', 'Selected', 'Qualified' and 'Tested' material.

The National Register of Basic Material for Ireland is the source of all information on approved forest basic material. Basic Material is the plant material from which Forest Reproductive Material (FRM) is derived and consists of Seed Stands, Seed Orchards, parent material held in archives, individual Clones and Clonal Mixtures. DAFM, as the national authority under the FRM Directive maintains the Register and approves all material. Each entry of Basic Material in the Register is given a unique register identity encoding: species, type of Basic Material, category of FRM to be produced, region of provenance, altitude and origin.

8.3 Needs, challenges and opportunities related to the use of forest genetic resources

To meet afforestation and reforestation requirements, a secure supply of appropriate reproductive material is required. In the medium to long term, it is likely that there will be a continued demand for the main commercial tree species, as well as an increasing demand for native species to serve native woodland establishment and rehabilitation programmes. An indigenous resource of high-quality reproductive material from home sources is a priority. Seed stands will remain a major source of seed, especially for broadleaves for the foreseeable future, while strategies to increase the production of '*Qualified*' and '*Tested*' FRM are also being prioritised, which has resulted in the establishment of a number of seed orchards in recent years.

There are however operational and environmental limitations to the production of seed in Ireland. This can include practical challenges such as the limited number of seed collectors, to the periodicity of seed years for some species. Furthermore, for species with an active tree improvement programme, it will take time for seed-producing orchards to come into production (see Section 10 management of forest genetic resources). While for some potential species recommended for use in the context of climate change, there are few stands in Ireland to serve as potential seed sources. As a result, the importation of FRM from suitable sources will continue to be important to meet forestation needs.

8.4 Priorities for capacity building and research

The current species, provenance and origin recommendations have been developed based on the results of trial assessment over many decades. However, changing environmental conditions associated with climate change are creating uncertainties about the future adaptability of forest tree species. Greater understanding of the adaptive potential of the range of tree species used in Irish forestry is needed to assess if the species list and provenances currently used need to be adjusted or expanded.

There also exists an opportunity to assess records on the source and origin of FRM deployed in Irish forests by consulting the certificates of provenance that accompany afforestation and

reforestation projects. For example, the growth performance of some seed origins or provenances could be assessed to indicate which material may be more suited for certain site types. This information could be used to revise provenance recommendations where necessary. Some tools have already been developed to aid decision making. The CLIMADAPT[33] research programme developed a decision support system for forest managers and policymakers, using soil and climatic information to assess species suitability and yield for individual sites under current and future climate change scenarios. While more recently the research programme aims to provide up to date information on provenance and seed origins adapted to future Irish climatic conditions[34].

There is need to develop and retain skilled researchers in the field, this is a challenge across the FGR area.

9 The state of genetic improvement and breeding programmes

This chapter provides an overview on the current state of tree improvement and breeding programs in Ireland, as well as the needs, challenges and opportunities in this area.

9.1 Approaches used for tree improvement & breeding

Progress has been made in the genetic improvement of many of the species used in Irish forestry over the last 70 years. Information from provenance trials has been used as the basis of seed source recommendations and tree breeding work has produced genetically improved planting stock for certain tree species. Tree breeding programmes were established in Sitka spruce and for some broadleaves, including birch (*Betula pubescens*) and alder (*Alnus glutinosa*). Breeding programmes were also established for pines, however, the programme for lodgepole pine (*Pinus contorta*) was suspended due to reduced peatland planting and the Monterey pine (*Pinus radiata*) programme was terminated due to limited suitability of the species (Table 7). Notable achievements in recent years include the commercialisation of the birch breeding programme. A programme of selection and breeding for tolerance to ash dieback programme has also been initiated[35]. There is also ongoing work to improve the quality of pedunculate and sessile oak, wild cherry, sweet chestnut and sycamore[36]. Sitka spruce has been the focus for conifer tree improvement and is the only species for which '*Tested*' FRM has been developed.[37] Sitka spruce

[33] CLIMADAPT is a web-based decision support system (DSS) based on Ecological Site Classification (ESC) developed for Irish Forestry.
[34] Teagasc, (2020). Fit Forests Project. Teagasc, Athenry, Galway, Ireland. https://www.teagasc.ie/crops/forestry/research/fit-forests-project/https://www.teagasc.ie/crops/forestry/research/fit-forests-project/
[35] https://www.teagasc.ie/crops/forestry/research/ash-resistance-to-ash-dieback/
[36] https://www.futuretrees.org/; https://www.fgrt.net/
[37] https://www.coillte.ie/our-business/our-products/nurseries/

is not a regular seed producer under Irish climatic conditions, as a result, seed orchards were not considered initially to be a feasible production strategy for producing improved FRM. Instead, deployment was initially through vegetative methods, using a process of somatic embryogenesis to provide copies of full-sib crosses, and then establishing hedges of this material, from which cuttings could be then taken. The theoretical advantage of this approach is that individuals with superior traits can be reproduced. The disadvantage is that the techniques result in higher per plant costs than plants propagated from seed. Largely for this reason, the micropropagation facilities were closed in 2016. A vegetative propagation programme is still carried out but using a simpler serial propagation approach. Resources have instead been directed towards the establishment of seed orchards. The first '*Tested*' seed orchards were established in 2011 and expanded in 2018 and 2020. Seed was collected for the first time in 2014, with the first major collection occurring in 2019.

Table 7 Status of forest tree improvement programmes in Ireland.

Species	Plus, trees	Provenance trials	Progeny trials	Clonal testing & development	Programme active	Highest Level of FRM on National Register
Ash	✓	✓	-	-	✓	*NA*[38]
Common alder	✓	✓	✓		✓	*Qualified*
Downy birch	✓	✓	✓	-	✓	*Qualified*
Pedunculate oak	✓	✓	✓	-	✓	*Selected*
Sessile oak	✓	✓	✓	-	✓	*Selected*
Sitka spruce	✓	✓	✓	✓	✓	*Tested*
Spanish (Sweet) chestnut	✓	-	-	-	✓	*Qualified*
Sycamore	✓	-	✓	-	✓	*Qualified*
Cherry	✓			✓	✓	*Qualified*
Beech	✓	-	-	-	×	*Selected*
Douglas fir	-	✓	✓	-	×	*Selected*

[38] Conventional tree improvement work suspended; efforts now concentrated on breeding for tolerance to ash dieback disease.

Species	Plus, trees	Provenance trials	Progeny trials	Clonal testing & development	Programme active	Highest Level of FRM on National Register
Japanese cedar	-	✓	-	-	×	*Selected*
Larch	-	✓	-	-	×	*Qualified*
Lodgepole pine	✓	✓	✓		×	*Qualified*
Monterey pine	✓	✓	✓	✓	×	*Selected*
Norway spruce	-	✓	✓		×	*Selected*
Scots pine	✓	-	-	-	×	*Qualified*
Silver birch	✓	✓	✓	-	✓	-
Western hemlock	-	✓	-	-	×	*Selected*
Western red cedar	✓	-	-	✓	×	*Selected*

9.2 Organisation of tree breeding

Prior to 1989 most work on forest genetic resources was undertaken by the Forest and Wildlife Service. Due to reorganisation, this work is now spread across several agencies. Tree improvement is now carried out by the semi state forestry company Coillte, Teagasc (Agriculture and Food Research Authority) and the Forest Genetic Resources Trust, with universities contributing via project-based research.

9.3 Use of current and emerging technologies used

Genomic selection and techniques such as marker-assisted selection are currently being investigated, notably for ash and Sitka spruce. For example, the Irish Sitka Spruce Tree Improvement Programme has been in operation for several decades and has selected individuals whose progeny produce the greatest yield of timber; however, up until recently genetic characterisation of the programme components had not been carried out. The breeding population have now been genotyped to ensure the genetic identities of the individuals. Work is currently under way by Teagasc to develop a genotyping platform for the Sitka spruce population and assess the viability of genomics-based breeding strategy. Genomic selection offers the potential to accelerate the selection of improved progeny by using DNA information to predict the breeding value of an individual tree and determine whether an individual will have desirable traits without having to wait for the traits to manifest.

9.4 Priorities for capacity building and research

A Recent COFORD Council Report *Sustainable Development and Conservation of Forest Genetic Resources 2020 -2030* set out a series of recommendations for the future development of Forest Genetic Resources in Ireland. In particular, the report highlighted the fragmented nature of tree improvement across several actors. It recommended that a National Tree Improvement Programme be developed to consolidate and co-ordinate tree improvement activities.

A list of priority species for improvement has been developed at a national level[39]. Species have been assigned a tier one or tier two position, based on the current or probable future demand for forest reproductive material and an associated tree improvement action is proposed for each species[40]. For instance, for Sitka spruce, the proposed action includes the continuation of the improvement programme. While for ash, the implementation of a breeding programme for tolerance to ash dieback disease is recommended. For other species, the recommendation

[39] COFORD (2020). Sustainable Development and Conservation of Forest Genetic Resources 2020 -2030. COFORD, Dublin Ireland.

included testing the suitability of improved material from foreign improvement programmes (Douglas-fir); or building on past gains (e.g., Scots pine).

10 Management of forest genetic resources

The main objective of this chapter is to describe how genetic considerations are taken into account in managing forests in Ireland.

10.1 Management of forest genetic resources in planted and natural forests

Genetic considerations are central to the choice of planting stock used for establishment, or their re-establishment after harvesting. Only specified species, origins/provenances are grant-aided. For commercial forest establishment this can include a range of non-native and native species adaptable to the Irish climate, while for grant aid schemes focused on native forest establishment or native forest conservation it is a requirement that planting stock should be of Irish origin.

In Ireland all plants used for forestry purposes 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. 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 Forest Service list of Accepted Tree Species for Grant Aid and Accepted Seed Origins/Provenances. 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 and suitability of the planting stock. Details of the provenance/origin of planted material also provide an essential forest management record for future reference.

10.2 Consequence of the changes in the forest sector for FGR and their management

To meet the needs of the current and future forestation requirements, a secure supply of appropriate reproductive material is required. Analysing past use of FRM can give some insight into determining future requirements. Tables 5 & 6 in section 8 provide a list of the main species currently used in Irish forestry, kilograms of seed and the plant number equivalent for the period 2015-2019. However, anticipating future demand is a difficult task, one that is subject to yearly variation. Forest nurseries, due to the lead-in time to produce planting material, are exposed to changes in forestation levels and other external factors. For instance, there has been a year-on-year steady decrease in afforestation, 2019 saw 3,550 ha afforested compared to a 10-year

average of just under 6,000ha (DAFM, 2020). This been further exacerbated recently by delays in issuing of felling licenses which has had a consequential impact on being able to plan for future supply and demand of FRM. However, in the medium to long term, if forest policy goals are to be realised, it is likely that there will be a continued demand for the main commercial tree species, as well as an increasing demand for native species. Therefore, an indigenous resource of high-quality reproductive material from home sources should be a priority. This can be achieved by increasing the proportion of genetically improved plant material which goes into production.

Seed stands will continue to be an important source of seed for the foreseeable future. These stands, having grown successfully in Ireland, will provide a basic level of improvement. Before their selection and registration, these stands will have been generally managed for timber production or occasionally as conservation areas.

It is important to acknowledge that due to the oceanic climate inherent in Ireland good seed years vary greatly with the species and by location within the country. For instance, species such as oak may produce small seed crops in scattered locations every few years but produce only major crops 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, averaging closer to once every 5 to 6 years. While the storage of conifer and some broadleaved seed can overcome supply difficulties some species, particularly the large-seeded broadleaves, cannot be stored for any great length of time.

10.3 Needs, challenges and opportunities for improving the management of forest genetic resources

There is a need to move to self-sufficiency, as far as practicable in forest reproductive material. The use of seed stands and seed orchards as the principal paths to self-sufficiency, allied to continuing investment in tree selection and breeding, and disease tolerance testing, with an emphasis on capturing sufficient genetic variation to enable adaptation, and growing of high-quality broadleaved forests. To attain a level of self-sufficiency the following measures have been identified by the national advisory FGR group (COFORD).

- Continued selection and registration of seed stands.
- An annual assessment of seed cropping is needed to provide a forecast of potential cropping ahead of time.
- Grant aid supports for management interventions aimed at increasing the frequency, quality and volume of commercial seed production and includes support for management planning.
- Prioritise the establishment of seed orchards

10.4 Priorities for capacity building and research in this area

There is need to develop and retain skilled researchers in the field, this is a challenge across the FGR area. As noted in earlier chapters, there is a need to revaluate the range of species, provenances and origins recommended for use in Irish. Where gaps in knowledge occur, set up new provenance trials to assess the adaptive potential to respond to ongoing changes in environmental conditions.

For native woodland establishment or native woodland rehabilitation, provenance selection should be investigated as a means of increasing climate change resilience. Such an investigation should include further study of the adaptive potential of native trees and consideration of a desirability/needs framework to assess the risk of maladaptation.

Part 5 Capacities and polices in forest genetic resources

11 Institution framework

The objective of this chapter is to provide an overview on the current state of capacities, institutions and policies related to the conservation, use and development of forest genetic resources

11.1 Organisation of forest genetic resources in Ireland

In Ireland, forest genetic resources are managed by several agencies, with the Department of Agriculture, Food and the Marine having overall responsibility for the sector (Table 8). A Forest Genetic Resources Working Group made up of relevant experts and stakeholders in the area was established under the COFORD Council in 2016. This group prepared a report *Sustainable Development and Conservation of Forest Genetic Resources 2020-2030, which* addresses key challenges faced by the sector, including climate change, and how forest genetic resources can be mobilised to increase the adaptive capacity of our forests. Other core elements addressed include how to ensure the sustainable supply and use of forest reproductive material, and steps required for the genetic conservation of our native, naturalised and introduced tree species.

Table 8 Organisations/entities involved in forest genetic resources in Ireland.

Organisation	Activity
Department of Agriculture, Food and the Marine (DAFM)	Overall responsibility for the development & regulation of FGR in Ireland. Responsible for implementing EU Council Directive 1999/105/EC on the marketing of forest reproductive material, and the OECD scheme for the certification of forest reproductive material moving in international trade. It is also responsible for the Plant Health Regulation (EU) 2016/2031. Operates grant aid schemes to support the appropriate use and conservation of genetic resources. Operates competitive research funding programmes covering agriculture, food and forestry.
Coillte	State forestry company. Active in tree improvement. Maintains several seed orchards and operates Ireland national tree seed centre.
Teagasc	Agriculture and food research authority. Research programmes in tree breeding & genetics, including ash breeding for tolerance to ash dieback, birch and alder improvement, the response of tree species to climate change, and genomic evaluation for the sustainable improvement of Sitka spruce.

Organisation	Activity
The National Parks and Wildlife Service (NPWS)	Responsible for National Parks and state-owned Nature Reserves, which contain the majority of native species in-situ conservation areas. The NPWS is the management authority in Ireland for the Convention in the International Trade in Endangered Species of Wild Fauna and Flora (CITES) and also for EU Regulation No. 511/2014 on Access to Genetic Resources and Benefit Sharing. It is the role of NPWS to designate legally protected areas and to advise on the conservation of protected habitats and species.
National Botanic Gardens (NBG)	Carries out research in FGR conservation, population genetics and genomics. Custodian of ex-situ conservation areas.
Forest Genetic Resources Trust (FGRT)	Charitable trust that supports the conservation, improvement and use of native and naturalised tree species in Irish forestry.
Research Performing Organisations	Relevant RPOs include Teagasc, the National Botanic Gardens and universities such as University College Dublin, Trinity College and Dublin City University, all of whom have recently undertaken research in the FGR area.
Other relevant stakeholders	Forest nurseries, registered foresters, private forest owners, The Society of Irish Foresters, Woodlands of Ireland.

11.2 Policy and regulatory framework

Forest genetic resources are recognised as being integral to the success of the forest sector within the current national policy framework, *Forests, products and people. Ireland's forest policy – a renewed vision* (DAFM, 2014), where it is recommended that: *"DAFM establish a representative National Forest Genetic Resources Advisory Group to guide all aspects of future genetic requirements and advice on the management of reproductive material and tree improvement and breeding programmes including formalising the national tree improvement programme".* It also includes a series of recommendations:

- The genetic quality of planting stock is well adapted and fit for purpose
- Use of genetically improved planting stock to increase both the minimum and average productivity levels

- The use of genetically improved planting material e.g., improved Sitka spruce, as distinct from genetically modified material, which will deliver improved timber quality and timber wood volumes will be supported
- National forest research competence maintained and developed in the FGR programme areas
- Consolidate work in critical forest research areas such as forest genetic resources, that require continuity of effort and national coordination to provide value for money and a level of expertise to achieve the potential of the forest sector

In early 2023, Ireland will publish a new forest strategy to 2030. It will complement a shared national vision for forests up to 2050. Ireland's new national forest strategy stresses the multiple functions of forests to the economy and society as well as the essential balance between the ecological, economic, and social functions of forests to ensure these three dimensions of sustainable development receive equal attention. The new Forest Strategy for Ireland identifies the need for forests to provide multiple benefits. This will mean applying the most appropriate forest management approach for the objectives set for a forest – whether that be even-aged forests with a commercial focus, closer-to-nature forests, semi-natural forests, agroforestry etc., - but within the overall framework of Sustainable Forest Management (SFM).

11.2.1 Climate Action Plan

The Climate Action Plan of Ireland[41], highlights a wide range of actions to reduce emissions and meet internationally agreed climate targets. The relevance of forest genetic resources to meeting climate objectives is included explicitly in the plan, where a commitment is made to *support the conservation and sustainable use of forest genetic resources, which is essential to protect the genetic diversity of our forests and improve resilience to climate change.*

11.2.2 Sectoral Adaptation Plan

DAFM published the Agriculture, Forest and Seafood Climate Change Sectoral Adaptation Plan under the National Adaptation Framework in 2019 (DAFM, 2019). Sectoral impacts and consequences highlighted in the plan include:

- reduced resilience and vitality of forests due to the impact of climate change.
- Increased risk of maladaptation leading to habitat and biodiversity loses.
- Reduced forest productivity, vitality and capacity to sequester carbon.
- Greater susceptibility to attack by harmful forest pests and disease.
- A change in pest and disease behaviour.
- Greater activity and impact of endemic pests and disease due to more favourable climatic conditions and the establishment of exotic pests and disease due to enhanced and favourable climate change-induced conditions.

[41] DCCAE (2021). Climate Action Plan 2021. Adelaide Rd. Dublin, Ireland.

Sectoral opportunities highlighted in the plan include the changes in plant growth habit and the opportunities that this presents in terms of increasing productivity for some species.

11.2.3 National biodiversity action plan

Ireland's third National Biodiversity Action Plan (2017-2021) was published in 2017 by the National Parks and Wildlife Service[42]. The plan sets a vision, that biodiversity and ecosystems in Ireland are conserved and restored, delivering benefits essential for all sectors of society and that Ireland contributes to efforts to halt the loss of biodiversity and the degradation of ecosystems in the EU and globally. The four high-level objectives included in the plan include:

- Mainstream biodiversity into decision-making across all sectors.
- Strengthen the knowledge base for conservation, management, and sustainable use of biodiversity.
- Increase awareness and appreciation of biodiversity and ecosystem services.
- Conserve and restore biodiversity and ecosystem services in the wider countryside.

11.3 Support schemes for the sustainable use and conservation of forest genetic resources

The Forest Genetic Resources Reproductive Material measure of the DAFM Forestry Programme 2014-2020 was introduced to support the conservation and development of Ireland's forest genetic resource. The primary objective of this scheme is to: increase the resilience, productivity and quality of Irish forests; increase self-sufficiency in tree seed production; provide for in-situ and ex-situ conservation of forest genetic resources; provide breeding populations of broadleaf and conifer species.

The principal benefits of the scheme are increased availability of more advanced and improved FRM to the forest sector, leading to increased productivity in wood production with economic and environmental co-benefits, including improved stem straightness and branching habit leading to higher timber recovery rates; increased wood density, resulting in better wood quality and a wider range of end-product use; better resilience to Irish climatic conditions and local pests and diseases as a result of capturing genetic adaptation in landraces; decreasing the risk of pests and diseases being introduced to Ireland by reducing the need to import material from abroad; in-situ and ex-situ conservation of genetic biodiversity; and enabling recurrent selection and improvement through linkages to tree improvement/breeding programmes. There is plans to

[42] NPWS (2017). National Biodiversity Action Plan 2017-2021. NPWS, Arran Quay, Dublin, Ireland.

enhance this scheme under the successor forestry programme 2023-2027 to provide additional supports for nursery sector and seed collectors[43].

DAFM also operates a Native Woodland Scheme under The Forestry Programme 2014-2020 and successor programme 2023-2027. It is aimed at protecting and enhancing Ireland's native woodlands; conservation and biodiversity are prioritised, with wood production encouraged where appropriate. In 2020 DAFM launched the Woodlands Creation on Public Lands scheme, the purpose of this Scheme is to encourage Public Bodies to establish new native woodlands on suitable land. Collectively both these initiatives will increase the cover of native woodland in Ireland.

11.4 Research and development on forest genetic resources

The following institutions are involved in the areas of plant and forest research, environmental management and molecular studies of relevance to FGR:

- National Botanic Gardens of Ireland
- National University of Ireland, Maynooth
- University College Cork
- University College Galway
- University College Dublin
- Teagasc – Agriculture and Food Development Authority
- Trinity College Dublin
- Waterford Institute of Technology

11.5 Needs and priorities for raising awareness of forest genetic resources

National initiatives focused on promoting the importance of FGR have been increased in recent years. For instance, the Forest Genetic Resources Reproductive Material measure of the Forestry Programme 2014-2020 was introduced in 2015. The scheme aims to support the conservation and development of Ireland's forest genetic resource, through the grant aid of management practices which facilitate in-situ conservation, and also grant aids the establishment of ex-situ conservation units such as genebanks or seed orchards.

Priorities and challenges in this space were recognised in the COFORD reports *Sustainable Development and Conservation of Forest Genetic Resources 2020-2030*, etc where it was recommended that an awareness programme, overseen by the Forest Genetic Resources Working Group be prepared and implemented to inform the industry, other relevant parties and the wider public, of the importance of forest genetic resources, forest reproductive material legislation,

[43] DAFM (2022). Irelands forest strategy Implementation Plan 2022 -2030 – Draft for public consultation. Department of Agriculture, Food and the Marine. Johnstown Castle Estate, Co. Wexford, Ireland

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.

While the importance and the utility of FGR are taught in some universities, it has not infiltrated into mainstream dialogue. There are no specialist personnel working exclusively in FGR in any Irish third level institution, but there are several active projects in FGR. The laboratory in the National Botanic Gardens has undertaken a number of projects on forest genetic resources conservation. Teagasc laboratories also undertake research on FGR.

12 International and regional cooperation on forest genetic resources

The objective of this chapter is to provide an overview of Irelands involvement in international and regional cooperation on forest genetic resources.

12.1 International and regional cooperation

The European Forest Genetic Resources Programme (EUFORGEN) is a collaborative initiative among European countries to promote conservation and sustainable use of forest genetic resources as well as protect and promote forest biodiversity. It was established in October 1994 to implement the Strasbourg Resolution S2 on the conservation of forest genetic resources of the first Ministerial Conference on the Protection of Forest in Europe. Ireland has been a member of EUFORGEN since 1998 and membership is supported financially by the Forest Service, while the programme is serviced by Forest Sector Development Division of the Department of Agriculture, Food and Marine.

Ireland is also a member of the OECD Forest Seed and Plant Scheme where FGR are receiving increased focus and attention.

12.2 Benefits gained from the international and regional cooperation

A key benefit of participation in EUFORGEN is the advice and support from EUFORGEN which facilitated the establishment of a gene conservation network under the EUFGIS project (European Information System on Forest Genetic Resources). EUFGIS is an online system for documenting and managing dynamic gene conservation units. To date, Ireland has seventeen units listed on EUFGIS including populations of oak, birch, mountain ash, alder, ash, aspen and Scots pine.

The importance of international collaboration was demonstrated in the response to ash dieback disease, where researchers from 35 countries, including Ireland, joined forces in an EU- funded COST Action FRAXBACK. The Action produced several documents on the consequences of ADB disease and guidelines for sustainable management of ash. Teagasc has further focused on

collaborating with several different European research agencies and has acquired and propagated population of ash genotypes putatively tolerant to ADB disease.

12.3 Needs, challenges and opportunities for strengthening the international and regional cooperation

The challenges associated with climate and biotic risk are not confined to Ireland and require international co-operation if meaningful solutions are to be realised. As previously discussed in Part 1 and 2, climate change will have a profound impact on our forests, for adaptive strategies outlined to succeed, it will require cooperation between countries and participation in European and international processes. Ireland represented through DAFM is involved in various European processes and collaborative groups (e.g., INTEGRATE Network, EUFORGEN) while researchers from Irish institutes regularity engage in European and international projects.

Part 6 Challenges and opportunities

13 Recommended actions for the future

In 2020 the Council of Forest Research and Development (COFORD) of Ireland produced an outline strategy for the Sustainable Development and Conservation of Forest Genetic Resources for the period 2020-2030. It brought together a full appraisal of current and past efforts in the use and conservation of FGR in Ireland, it outlined genetic options for adapting forests to climate change and biotic risk and included a series of actions necessary to improve the resilience of forests. In doing so it provided several recommendations for the future, including: the coordination of FGR activities, knowledge transfer and promotion, forest reproductive supply needs, research and development requirements, and gene conservation. High-level actions from this report are summarised below according to the four priority areas of the Global Plan of Acton on FGR.

Availability of information on FGR

- The current species, provenance and origin recommendations on FGR use are based on data captured in trials over many decades. However, changing environmental conditions associated with climate change are creating uncertainties about the future adaptability of forest tree species. An understanding of the adaptive potential of the range of tree species used in Irish forestry is needed to assess if the species and provenances currently used need to be adjusted or expanded. Evidence-based information relevant to Irish conditions is needed to inform policymakers, forest owners and the forest industry about both the selection and utilisation/deployment of the most appropriate FGR. Some tools have already been developed to aid decision making and further research is ongoing to provide more up-to-date information.
- For native species, the genetic component of extant forest trees needs to be studied in greater detail to assess adaptive potential.
- To develop the required information sustainable use and conservation of Forest Genetic Resources should be included as a thematic area of research theme in national competitive research calls.

Policies, institutions and capacity building

- That the national advisory group oversee the monitoring and implementation of FGR-related actions.

- National and international cooperative research networks and programmes continue to be encouraged and facilitated.
- Policymakers, forest managers and owners should focus on diversity, both between species and within species, to increase the adaptive capacity of Irish forests.
- Sustainable use and conservation grant aid measures are introduced into the national forestry programme to enhance the quality and quantity of appropriate reproductive material for forestation.
- That research supports for the sustainable use and conservation of forest genetic resources are strengthened.

Use, Development and management of FGR

- Steps are taken to increase the indigenous capacity of FRM production and availability of genetic resources for afforestation and reforestation.
- There is a continued investment in seed stand and seed orchard development.
- That a National Tree Improvement Programme be considered as part of a Longer-Term Forest Research Centre of Excellence.
- Tree improvement programmes should implement selection and breeding strategies aimed at increasing climate change resilience.
- For native woodland establishment or native woodland rehabilitation, provenance selection should be investigated as a means of increasing climate change resilience. Such an investigation should include further study of the adaptive potential of native trees and consideration of a desirability/needs framework to assess the risk of maladaptation.
- Climate change adaptation strategies for adapting forests to climate change and mitigating biotic risk are considered and implemented.
- An awareness programme should be prepared to raise the importance of forest genetic resources, forest reproductive material legislation, seed collection systems, and the promotion of the benefits of the sustainable use of forest reproductive material.

FGR Conservation

- Continue to implement the national strategy for in-situ conservation of native tree species and strengthen the network of Gene Conservation units.
- Update the inventory of ex-situ FGR at the national level.
- Formalise approach to dynamic conservation of important non-native species.
- Maintain links with pan-European processes for FGR conservation through EUFORGEN and the EUFGIS network.