THE SECOND REPORT
ON THE STATE
OF THE WORLD'S

FOREST GENETIC RESOURCES

COUNTRY REPORT

PORTUGAL

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.

Instituto Nacional de Investigação Agrária e Veterinária, I.P.

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PORTUGAL

[APRIL 2021]

Executive Summary

Forest genetic resources are the heritable materials maintained within and among tree and other woody plant species that are of actual or potential economic, environmental, scientific, or societal value. Most tree species have high levels of genetic diversity, offering great potential for increasing the production of both wood and non-wood forest products, as well as for improving the provision of environmental services. Conservation of forest genetic resources can be defined as the policies and management actions taken to assure their continued and availability and existence (FAO, 2014b).

Activities on genetic conservation of forest trees started in Portugal 1991 after the country had signed Resolution 2 of the Strasbourg Ministerial Conference held in 1990. Portugal has not yet established a national program for the conservation of forest genetic resources but various efforts in this regard have been carried out. Cork oak (*Quercus suber*), representing widely distributed tree species, was the first species for which gene conservation efforts were started.

Aiming to frame, promote and access on genetic improvement and conservation of forest genetic resources (FGR) activities developed by the Portuguese public administration, an operational program, PROGEN, was devised to support, at a national level, the financing of projects aimed at genetic improvement and conservation of forest resources. At an operational level, in 2020, the first five projects focused on these issues were approved. Reliable information on diversity status and trends for maritime pine, cork oak, Mediterranean stone pine, prickly juniper and white crowberries are the main objectives of those financed projects, which will be available by the end of 2022.

Abbreviations and Acronyms

BM	Basic Material
CBD	Convention on Biological Diversity
CENASEF	"Centro Nacional de Sementes Florestais"
cp DNA	Chloroplast DNA
DRAP	"Direção Geral de Agricultura e Pescas"
EBLUP	Empirical Best Linear Unbiased Predictor
ENF	"Escaroupim" National Forest
ESAC	"Escola Superior Agrária de Coimbra"
EST	Expressed Sequence Tag
EU	European Union
EUFGIS	European Information System on Forest Genetic Resources
EUFORGEN	European Forest Genetic Resources Program
FAO	Food and Agriculture Organization of the United Nations
FGR	Forest Genetic Resources
FOREMATIS	Forest Material Information System
FOREST EUROPE	Ministerial Conferences for the Protection of Forests in Europe
FRM	Forest Reproductive Material
GCU	Genetic Conservation Units
ICNF	"Instituto da Conservação da Natureza e das Florestas, I.P."
INIAV	"Instituto Nacional de Investigação Agrária e Veterinária, I.P."
IPGRI	International Plant Genetic Resources Institute
IPB	"Instituto Politécnico de Bragança"
ISA/UL	"Instituto Superior de Agronomia/Universidade de Lisboa"
ISSR	Inter-Simple Sequence Repeats
IUFRO	International Union of Forest Research Organizations
LNF	"Leiria" National Forest
NFI	National Forest Inventory
NFP	National Focal Point
NFS	National Forest Strategy
NRBM	National Register of Basic Material
OECD	Organization for Economic Co-operation and Development
PROGEN	Operational Program for the Conservation and Improvement of Forest Genetic Resources in the Public Administration
PWD	Pine Wilt Disease
PWN	Pinewood Nematode
RJAAR	Regime Applicable to Afforestation and Reforestation
SCI	Site of Community Importance
SNPs	Single Nucleotide Polymorphisms
UNAC	"União da Floresta Mediterrânica"
UNFF	United Nations Forum on Forests

UTAD	“Universidade de Trás-os-Montes e Alto Douro”
VNF	“Vimeiro” National Forest

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The report was prepared by a core team from two public institutions dealing with forest genetic resources, INIAV and ICNF. The first one working on research and the second on management. The team was constituted by four elements, Isabel Carrasquinho (INIAV), as Nacional Focal Point on forest genetic resources and coordinator, José Manuel Rodrigues (ICNF), Dina Ribeiro (ICNF) and Helena Marques (ICNF). This report would not have been possible without the close collaboration of Vanessa Quico, Emídio Santos and João Herdeiro from ICNF; Eugénia Gouveia and Maria do Sameiro Patrício from IPB; Maria Helena Almeida, Paula Soares and Filipe Costa e Silva from ISA/UL; Rita Costa, INIAV; Maria João Gaspar, UTAD; Filomena Gomes, ESAC; Conceição Santos Silva, UNAC and Nuno Borralho from The Navigator Company.

Part 1: The contributions of forest genetic resources to sustainable development

Chapter 1. Value and importance of forest genetic resources

Helena Marques [1] Dina Ribeiro[1] and Isabel Carrasquinho[2]
[1] ICNF; [2] INIAV

1.1 The role of forests and forest sector in Portugal

Portuguese forest has an unquestionable economic importance, as a base of developed industrial chains, in social terms, as a guarantee of employment in rural areas, avoiding human desertification, and in environmental terms, as it contributes for the regulation of the water system, for soil preservation, and for microclimate protection. The forest is also an important support for job creation and presents diversification of activities, some of which are quite important in disadvantaged regions.

Since 2000, the forestry sector represents an average of 10% of Portuguese exports. The trade balance has consistently exceeded EUR 2 billion. In 2019, this indicator verifies values in the order of 2.6 billion euros. Consistently, in the same period, the rate of exports over imports was over 200%. The forestry sector is also responsible for the creation of approximately 94.3 thousand jobs, of which almost 70.8 thousand correspond to direct jobs in the primary sector and forest-based manufacturing industries.

An analysis of the Portuguese forest by species identifies a forest associated with a dominant function of woody production (maritime pine, other resinous and eucalyptus), while other types of forest demonstrate a more multifunctional vocation, in which cork, fruits, seeds, grazing and hunting are important components of its economic sustainability (cork oak, stone pine, chestnut tree, strawberry tree, carob tree, holm oak). Besides woody production, some forest types, such as oaks and other hardwoods, stand out for conservation of the water, fisheries, and biodiversity.

1.2 The contributions of forest genetic resources to sustainability

To ensure sustainable management of forests, the genetic resources of forest trees must be conserved and developed, whether they exist as trees in planted forest, natural forest or protected conservation stands, or as seeds or tissue cultures in storage (FAO, 2014a). The existence of genetic variability ensures the survival, adaptation, and evolution of forest species in the face of environmental changes, helping to maintain their vitality in the emergence of new pests or diseases. In fact, in the last years, Portuguese forest have been affected by these problems, namely the aggravation of pests and the extent and recurrence of fires, which have huge repercussions on the sustainability of forest management.

In Portugal, the use of improved plants was identified as a strategic line to ensure and increase the economic production of stands and it is included in the National Strategy for Forests (NSF) (Resolution of the Council of Ministers nº 6-B/2015, of February 4) as the priority objective "Improvement of Forest Management and Stand Productivity". This strategy, updated in 2015, takes as its new vision the sustainability of forest management assumed by Portugal within the Pan-European process for the sustainable management of continental forests, the Ministerial Conference for the Protection of Forests in Europe (FOREST EUROPE) and the United Nations Forum on Forests (UNFF). In fact, the European Union's policies on forestry policies, while respecting the member states' competencies, are likely to have an impact on the different countries through the definition of common and comprehensive strategies.

The Portuguese Standard, “NP 4406”, published in 2014, constitutes an application of the pan-European criteria for sustainable forest management. This “NP 4406” aims to specify the requirements for any forest management unit to define a management that attends to the legal requirements, the criteria for sustainability and the potential social, economic, and environmental impact. It is addressed to all Portuguese forest producers who wish to obtain the recognition of their products, demonstrating that they are coming from sustainable forest management operations. The “Maintenance, conservation, and appropriate enhancement of biological diversity in forest ecosystems”, criterion 4, is evaluated by the quantitative indicator “Genetic resources” which refers to areas managed for conservation and utilisation of forest tree genetic resources (*in situ* and *ex situ* genetic conservation) and areas managed for seed production. This indicator is justified as these resources are a vital component for sustainable forest management.

Portugal ratified the Convention on Biological Diversity (CBD) in 1993 (Law no. 21/93, of June 21). Now, Portugal is defining a legal framework for the national application of the Nagoya Protocol. The CBD is the first and most important international instrument on the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. The international Nagoya Protocol extending the scope of Article 15 of the CBD (Access to genetic resources), enhances significant benefits for the conservation and use of biodiversity by regulating their use and contributing to the development and human well-being.

Aiming to frame, promote and access on genetic improvement and conservation of forest genetic resources (FGR) activities developed by the Portuguese public administration, an operational programme, PROGEN, was devised (INIAV and ICNF, 2018). This document was the basis to support, at a national level, the financing of projects aimed at genetic improvement and conservation of forest resources. At an operational level, in 2020, the first five projects focused on these issues were approved. Reliable information on diversity status and trends for maritime pine (*Pinus pinaster* Aiton), cork oak (*Quercus suber* L.), Mediterranean stone pine (*Pinus pinea* L.), prickly juniper (*Juniperus oxicedrus* L.) and white crowberries (*Corema album* L. D. Don) are the main objectives of those financed projects, which will be available by the end of 2022.

1.3 Needs and priorities

The sustainable management of forests and of trees in agroforestry systems requires a better understanding of the specific features of forest trees and their genetic diversity, and how they can be best conserved, managed and utilized (FAO, 2014b). Identified needs and priorities to enhance the contributions of forest genetic resources towards relevant sustainable development goals are:

- Enhance communication and awareness of forest genetic resources among all the forests actors.
- Promote coordination of conservation objectives and utilization practices in production-oriented and multiple use of forests.
- Promote operational afforestation programs with genetically appropriated tree seeds in quantity and quality (certified).
- Support and conduct research specifically in the fields of conservation, testing, breeding, and sustainable use to enhance appropriate genetic material to current and future conditions.

Part 2: State of diversity in forests and woodlands

Chapter 2. State of forests

Emídio Santos [(1)] , Dina Ribeiro [(1)] and José Manuel Rodrigues [(1)]

[(1)] ICNF

2.1 State of forests and trends in their management

Forests are important global resources and provide a wide range of environmental, cultural, economic and social benefits and renewable natural products such as timber, fuel, fiber, food and chemical resources, with countless applications and with a clear influence on the lives of rural communities. At the ecosystem level, they provide vital services, particularly in combating desertification, protecting water courses, regulating the climate, maintaining biodiversity, and preserving social and cultural values.

The revision of the National Forest Strategy (NFS), approved by the Resolution of the Council of Ministers No. 6-B/2015 of February 4, even states that the national forest has an undeniable importance in economic terms, as the basis for developed industrial sectors, and in social terms, as a guarantee of employment in rural areas and in environmental terms, as a guarantee of regulation of the water system, soil preservation and microclimate protection. Therefore, the sustainability of forest management should be highlighted, in compliance with the criteria established at international level, assumed by Portugal within the Pan-European process for the sustainable management of continental forests, the Ministerial Conference for the Protection of Forests in Europe (FOREST EUROPE) and the United Nations Forum on Forests (UNFF).

Indeed, the Portuguese forest is the support of a competitive industrial sector, both in the domestic and foreign markets, where some forestry sectors are world leaders, and is also an important source of job creation and income for the rural economy with diversification of activities, some of which are important in poor regions. It produces a multitude of other goods and services, with emphasis on its contribution as a carbon sink, which should be enhanced through measures to combat deforestation and support for sustainable management.

The latest National Forest Inventory (NFI) show that, after a period of forest area growth throughout the 20th century, there has been a relative stabilization of the forest area in Portugal, reflecting the negative impact of some risk factors, such as forest fires, pests, and decline phenomena in some forest systems. These factors have repercussions on the sustainability of forest management, namely the loss of forest area and storage stock due to the extent and recurrence of forest fires, the appearance of new forest pests and overexploitation of forests as a reaction to loss of income, reflected in an unstable situation with periodic cycles of loss in area, biodiversity, and carbon storage, only partially offset by reforestation of rural areas.

The maintenance of sustainable forest management is based on continuing the collective management of forest areas, taking measures to reduce the area burned (which are aggregated in the National Plan for Integrated Management of Rural Fires), minimizing the risks of introduction and dispersion of forest pests (with observance of the guiding principles of prevention and control set out in the Operational Program for Forest Health), in the continuity of certification, in the maximization or diversification of resources from forest spaces (resin exploitation, nuts, mushrooms, hunting) and in the implementation of programs or plans at the landscape scale with a focus on carbon storage, integrating a player that contributes to the national decarbonization goals.

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

Some relevant changes in the forestry sector should be noted, including a change of focus in national forestry policies, with the transition of forestry from agriculture to environment, resulting in a greater focus on environmental issues, in particular the performance of forest areas as carbon storage and in increasing biodiversity (limiting the expansion of eucalyptus). Extreme importance has also been given to solving the impact of rural fires (political level, planning and organization).

In the next National Forest Inventory, greater focus should be given to the evaluation of forest genetic resources, in the sense of increasing knowledge that will result in their inventory and cataloguing, contributing to their conservation.

2.3 Needs and priorities

Aware of the unquestionable importance of the Forest, which even gains a renewed centrality in terms of climate strategy, both European and national, and a recognized role as a center within the scope of the objective of carbon neutrality, but also aware of the increasing pressures to which it is subject, namely threats of a phytosanitary nature that weaken ecosystems and put their sustainability at risk, it is absolutely urgent to adopt a phytosanitary risk management approach. The detection of harmful biotic agents, as early as possible, as well as a timely and effective response, which avoid their introduction and dispersion in new territories, and whose impacts, direct and indirect, will not be overlooked.

This is a paradigm that will have to be integrated into our strategy of action, oriented towards the management of Forest Resources in the broadest sense, including genetic resources (depending on the risks), towards innovation (bringing new knowledge) and towards the modernization of processes (instituting more efficient mechanisms for action), based on clear purposes and translated into concrete and very fast actions and that aims to concretize and combine efforts integrating lines of action that have been pursued, but that should be interconnected, especially given the growing vulnerabilities and risks reflected in a new attitude to forest management and exploitation necessarily, articulated with aspects related to nature conservation and biodiversity. Therefore, it is crucial to develop a database for the Portuguese forest genetic resources.

Chapter 3. State of other wooded lands

Emídio Santos [(1)], Dina Ribeiro [(1)] and José Manuel Rodrigues [(1)]

[(1)] ICNF

3.1 State of other wooded lands and trends in their management

Forest areas have been valued, including areas of wooded lands and grazing, and this valuation has been carried out in a global manner, considering not only the values of direct (commercial) use of traditional forest products such as timber, cork and resin, but also others that are less accounted for, such as honey, fruit, mushrooms, aromatic plants, forestry, grazing, hunting, fishing in inland waters. Regarding the values of indirect use, such as those referring to the protection of soil and water resources, carbon sequestration, landscape protection, recognition of specific habitats with value for biodiversity, and recreation, they have also contributed to that valuation. And these are issues in which there has been high public intervention. The Portuguese forest planning system has developed a process of identification and compatibility of goods and services associated with forest use, which are applicable both at the regional level and at the level of the forest management unit.

In a country like Portugal, with a strongly humanized territory, the different functions are necessarily coincident in most of the territory, in obviously different gradations, since there are no wild spaces with the dimension to satisfy the wide range of needs for goods and services in an exclusive way, in segregated compartments.

Some negative trends should be highlighted, namely the existence of invasive exotic species, the overall loss in value when compared to forested areas, which potentiate situations that are favorable to the propagation of fire.

3.2 Drivers of change in other wooded lands, and their consequences for forest genetic resources

The control of invasive alien species is an issue that has been considered strategic, as well as the valorization of other natural resources, the increase of range management as a control on rural fires through the reduction of woody fuel, and the greater focus on the evaluation of genetic resources in the next NFI.

Valuing those spaces (for the biodiversity and genetics resources they contain) starting by classifying them in a category other than "other wooded land".

3.3 Needs and priorities

Deepen the knowledge of the flora that make up this category and its possible uses, particularly medicinal plants.

Promote the recognition and value of these spaces by increasing knowledge about genetic resources, particularly species that are endemic to the Iberian Peninsula, those with commercial value, as they are the basis of a value chain that leads to products of excellence (honey, essential oils, medicinal, aromatic, and ornamental plants).

Promote its conservation as an identifying and differentiating element of rural landscapes to be provided by enlightened and quality tourism.

Make compatible the reduction of fire risk in forest areas withs elective cutting of undergrowth, focusing on those with low diversity and preserving those that are endemic or highly evolved in ecological series.

Chapter 4. State of diversity between trees and other woody plant species

Dina Ribeiro[1] Helena Marques [1] and Isabel Carrasquinho [2]

[1] ICNF; [2] INIAV

Portugal lists a total of 84 different forest species managed and utilized in the forestry context (Table 4.1). From that total, 23 are shrubs and 19 are considered rare species. The list does not include trees used in social areas such as: streets and green areas in built-up areas, gardens, and parks in urban environments.

Table 4.1. Native (N) and exotic (E) forest species (trees and shrubs) in Portugal.

Species (scientific name)	Native (N) /Exotic (E)	Occurrence	Obs.
1. Conifers			
Juniperus communis L. ssp. *nana* Syme	N	Frequent	shrub
Juniperus navicularis Gand.	N	Rare	shrub
Juniperus oxycedrus L.	N	Frequent	
Juniperus turbinata Guss.	N	Frequent	
Pinus pinaster Aiton	N	Predominant	
Pinus pinea L.	N	Predominant	
Pinus radiata D. Don	E	Rare	
Pinus sylvestris L.	N	Frequent	
Pseudotsuga menziesii Mirb.	E	Frequent	
Taxus baccata L.	N	Rare	
2. Hardwood			
Acer monspessulanum L.	N	Occasional	
Acer pseudoplatanus L.	N	Occasional	Invasive
Alnus glutinosa (L.) Gaertner	N	Abundant	
Amelanchier ovalis Medic.	N	Rare	shrub
Arbutus unedo L.	N	Abundant	
Betula pubescens Ehrhart	N	Abundant	
Buxus sempervirens L.	N	Occasional	shrub
Castanea sativa L.	N	Predominant	
Celtis australis L.	N	Occasional	
Ceratonia siliqua L.	N	Predominant	
Chamaerops humilis L.	N	Occasional	shrub
Cornus sanguinea L.	N	Rare	shrub
Corylus avellana L.	N	Occasional	shrub

Species (scientific name)	Native (N) /Exotic (E)	Occurrence	Obs.
Crataegus monogyna Jacques	N	Abundant	shrub
Erica arborea L.	N	Abundant	
Erica scoparia L.	N	Abundant	shrub
Eucalyptus globulus	E	Predominant	
Euonymus europaeus L.	N	Rare	shrub
Fagus sylvatica L.	N	Frequent	
Frangula alnus Miller	N	Abundant	
Fraxinus angustifolia Vahl	N	Abundant	
Ilex aquifolium L.	N	Frequent	
Laurus nobilis L.	N	Frequent	
Ligustrum vulgare L.	N	Occasional	shrub
Malus sylvestris (L.) Miller	N	Occasional	
Myrica faya Aiton	N	Frequent	
Myrica gale L.	N	Rare	
Myrtus communis L.	N	Abundant	shrub
Nerium oleander L.	N	Frequent	shrub
Olea europaea L.	N	Abundant	
Phillyrea angustifolia L.	N	Abundant	
Phillyrea latifolia L.	N	Abundant	
Pistacia lentiscus L	N	Abundant	shrub
Pistacia terebinthus L.	N	Frequent	shrub
Populus alba L.	N	Frequent	
Populus nigra L.	N	Frequent	
Populus tremula L.	N	Rare	
Prunus avium L.	N	Abundant	
Prunus insititia L.	N	Occasional	
Prunus lusitanica L. subsp. *lusitanica*	N	Rare	
Quercus x *airensis* Franco & Vasc. [1]	N	Occasional	
Quercus x *andegavensis* Hy [2]	N	Occasional	
Quercus canariensis Willdenow	N	Rare	
Quercus coccifera L.	N	Abundant	
Quercus x *coutinhoi* Samp. [3]	N	Occasional	
Quercus faginea Lambert	N	Predominant	
Quercus x *jahandiezii* [4]	N	Rare	
Quercus x *mixta* Colm. [5]	N	Occasional	
Quercus x *neomarei* A. Camus [6]	N	Occasional	
Quercus pyrenaica Willdenow	N	Predominant	
Quercus rivasmartinezii (Capelo & J.C. Costa)	N	Rare	
Quercus robur L.	N	Predominant	
Quercus rotundifolia Lambert	N	Predominant	
Quercus suber L.	N	Predominant	

Species (scientific name)	Native (N) / Exotic (E)	Occurrence	Obs.
Retama monosperma (L.) Boiss.	N	Abundant	shrub
Rhamnus alaternus L.	N	Abundant	shrub
Rhamnus cathartica L.	N	Rare	shrub
Rhododendron ponticum L. ssp. *Baeticum* (Boiss. & Reuter) Hend.-Mazz.	N	Occasional	
Salix alba L.	N	Abundant	
Salix arenaria L.	N	Frequent	shrub
Salix atrocinerea Brotero	N	Abundant	
Salix caprea L.	N	Rare	
Salix x *erytoclados* Simonkai [7]	N	Frequent	
Salix fragilis L.	N	Frequent	
Salix x *multidentata* T. E. Díaz& E. Puente [8]	N	Frequent	
Salix x *pseudosalviifolia* T.E. Díaz& Puente	N	Frequent	
Salix purpurea L.	N	Frequent	
Salix x *rubens* Schrank [9]	N	Frequent	
Salix salviifolia Brotero [10]	N	Frequent	
Salix x *secalliana* Pau & C. Vicioso	N	Frequent	
Salix triandra L.	N	Occasional	
Sambucus nigra L.	N	Frequent	shrub
Sorbus aria (L.) Crantz	N	Rare	
Sorbus aucuparia L.	N	Frequent	
Sorbus domestica L.	N	Occasional	
Sorbus latifolia (Lambert) Persoon	N	Rare	
Sorbus torminalis (L.) Crantz	N	Rare	
Tamarix africana Poiret	N	Abundant	
Tamarix canariensis Willdenow	N	Frequent	
Ulmus minor Miller	N	Occasional	
Ulmus glabra Hudson	N	Rare	
Viburnum lantana L.	N	Rare	shrub
Viburnum opulus L.	N	Occasional	shrub
Viburnum tinus L.	N	Abundant	shrub

Source: ICNF
[1] *Q. coccifera* x *Q. rotundifolia;* [2] *Q. robur* x *Q pyrenaica;* [3] *Q. robur* x *Q. faginea* ssp. Broteroi; [4] *Q. canariensis* x *Q. faginea* ssp. Broteroi; [5] *Q. rotundifolia* x *Q. suber;* [6] *Q. pyrenaica* x *Q. faginea* ssp. *Broteroi;* [7] *Salix alba* x *S. trianda* ssp. *Discolor;* [8] *S. atrocinerea* x *S. trianda* ssp. *Discolor;* [9] *S. alba* x *S. fragilis* (= *Salix neotricha* Görz); [10] Habitat Directive, just the subspecies *australis* Franco; [11] *S. atrocinerea* x *S. salviifolia*

Under the legal regime applicable to afforestation and reforestation (RJAAR), which came into force on October 17, 2013, authorized or validated (re)afforestation actions, actions approved under public forestry support programs and/or actions carried out in areas under the management of ICNF accounted to 120 369 hectares, of which 69% are related to eucalyptus, 14% to quercine, including cork oak (10%) and holm oak (1%), 7% to stone pine and 4% to maritime pine.

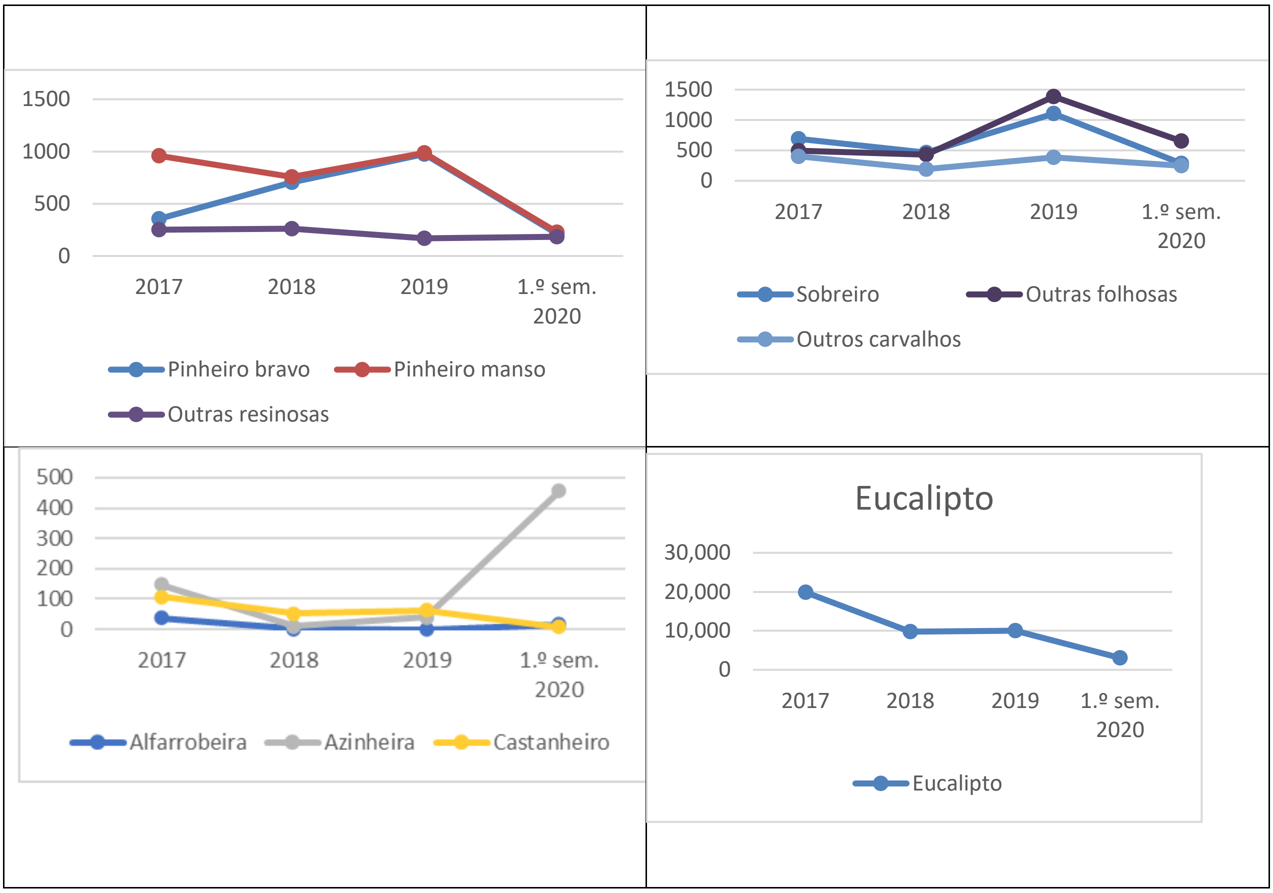

Fig 4.1. Trends in the use of species for afforestation between 2017 and first half of 2020.

Between 2017 and the first half of 2020, considering to the main forest species used in Portugal, there was a general declining trend in the area planned for afforestation/reforestation for (Figure 4.1). Forest fires, interactions of climate changes with existing or exotic pests, diseases are the main drivers of changes affecting production, and forest composition. However, during that period, it should be noted that in 87% of the 120,369 hectares of afforestation/reforestation carried out and planned, around 45 species were used, although with a remarkably diverse proposed occupation area, as shown in Table 4.2.

Table 4.2. Areas(ha) and species approved for afforestation between 2013-2020.

Species (scientific names)	Approved area for afforestation (ha)						
	< 100	100-200	200-500	500-1000	1000-5000	5000-10000	>10000
Acer pseudoplatanus	X						
Alnus glutinosa	X						
Arbutus unedo					X		
Betula celtiberica		X					
Castanea sativa			X				
Cedrus atlantica	X						
Ceratonia siliqua	X						
Chamaecyparis lawsoniana	X						
Cupressus lusitanica	X						
Cupressus spp.	X						
Eucalyptus nitens					X		
Eucalyptus spp.				X			
Eucalyptus globulus							X
Fagus sylvatica	X						
Fraxinus angustifolia		X					
Fraxinus excelsior	X						
Ilex aquifolium	X						
Juglans nigra	X						
Juglans regia	X						
Liquidambar styraciflua	X						
Other broadleaves			X				
Other conifers	X						
*Paulownia**		X					
Pinus halepensis	X						
Pinus nigra	X						
Pinus pinaster					X		
Pinus pinea						X	
Pinus radiata				X			
Pinus spp.	X						
Pinus sylvestris	X						
Platanus spp.	X						
Populus alba	X						
Populus alba		X					
Populus nigra	X						
Populus spp.	X						
Prunus avium	X						
Pseudotsuga menziesii	X						
Quercus faginea			X				
Quercus pyrenaica			X				
Quercus robur				X			
Quercus rotundifolia				X			
Quercus rubra				X			
Quercus spp.	X						
Quercus suber					X		
Salix spp.	X						

Source: ICNF; * Before the use of the species was banned in 2019

Chapter 5. State of diversity within trees and other woody plant species

Isabel Carrasquinho [1]

[1] INIAV

5.1 State and technologies used for assessing genetic diversity in Portugal

In this chapter, forest genetic diversity was considered at two stages: within species and within populations, at a provenance and progeny/clonal levels, respectively. Table 5.1 lists the forest species that have been evaluated for genetic variability at a population level.

In Portugal, provenance trials for the main economic forest tree species, such as: maritime pine (*Pinus pinaster* Ait.), Mediterranean stone pine (*Pinus pinea* L.), cork oak (*Quercus suber* L.) and eucalyptus (*Eucalyptus globulus* Labill.) were established in the second part of the 20th century. Maritime pine, cork oak and eucalyptus genetic variation have also been evaluated on progeny and clonal analysis. For these species, both quantitative and molecular methodologies were used to characterize genetic variability.

Table 5.1. Forest species for which genetic variability has been evaluated at different genetic levels.

Species		Type of material evaluated (genetic level)	Adaptive and production characters assessed	Molecular characterization
Scientific name	**Native (N) or exotic (E)**			
Pinus pinaster	N	Provenances families clones	X	X
Pinus pinea	N	Provenances	X	
Quercus suber	N	Provenances families	X	X
Eucalyptus globulus	E	Provenances families clones	X	X

Genetic knowledge of genetic variation patterns has been published in international and national research journals and disseminated in conferences. Based on the maritime pine Portuguese provenances and progeny trials, several research studies related to quantitative genetic and molecular markers have been published regarding productive and disease resistance traits (Ribeiro *et al.*, 2001; Aguiar *et al.*, 2003; Correia *et al.*, 2008; Correia *et al.*, 2010; Gaspar *et al.*, 2011; Carrasquinho *et al.*, 2018).

Cork oak provenance and progeny trials, established in 1998, gave rise to several scientific papers on genetic variability not only focused on quantitative methodologies but also on molecular markers (SNPs, cpDNA, EST and genotyping sequencing). All these methodologies showed significant genetic variation for both adaptative, survival, growth and form (Sampaio *et al* 2016, Sampaio *et al*, 2019) and neutral traits (Costa *et al*, 2011; Modesto *et al*, 2014; Pereira-Leal *et al*., 2014; Pina-Martins *et al*, 2019; Vanhove *et al*., 2021). Cork oak populations differed significantly in the timing of budburst, which can affect pest activity. Additionally, it was shown that growth traits and spring shoot phenology are under high genetic control (Sampaio *et al*, 2021).

For Mediterranean stone pine provenances, genetic variation was detected for survival, total height, and diameter at breast height at different ages, using quantitative genetics methodologies (Carrasquinho and Gonçalves, 2013).

The first *Eucalyptus globulus* provenance trial in Portugal was established in 1985 on six sites to evaluate genotype x environment interaction on growth, survival, and wood quality. The results suggested that far from its natural area *E. globulus* had developed landraces. Concerning growth and quality the Portuguese population spread all over the range of variation (Almeida *et al*., 1995). Quantitative and molecular genetic studies had helped to clarify the origin of the Portuguese landrace. A southern and eastern Tasmania origin seems to be the origin for the Portuguese landrace (Costa et al., 2017).

Regarding minor forest tree species, surveys and inventories of intraspecific genetic variation are still scarce. However, for the forest shrub, white crowberry (*Corema album*) genetic diversity was found (Jacinto et al., 2020). The analyses provided by the ISSR makers showed that genetic diversity was higher between populations and lower within. About the morphological traits a high morphological diversity was showed, but no signal regarding geographic location. The Mantel test between genetic and morphological data had a low correlation.

As far as it is known, published studies concerning the trends in genetic diversity are not available. Nevertheless, genetic diversity loss, especially in major forestry species, can be expected. The reasons include forest fires, pests and/or fragmentation of landscapes, regeneration with bred forest reproductive material and forest damage. One of the main loss of genetic variation is expected when using few clones in forestry.

5.2 Needs and priorities

- Improve understanding and trends on genetic diversity of important or priority species.
- Study the relations among neutral data, genomic data and assessed phenotypical variation.
- Increase knowledge on how the new technologies can help setting priorities on Forest genetic resources and to identify populations on risks.

Part 3: State of forest genetic resources conservation

Chapter 6. *In situ* conservation of forest genetic resources

Isabel Carrasquinho[(1)] Helena Marques [(2)] Maria João Gaspar [(3)]

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Conserving genetic resources in their natural environment, whether in production forests or in protected areas, is called *in situ* conservation (FAO *et al.*, 2001). *In situ* conservation is also applied to artificial regenerated populations whenever planting or sowing was carried out, without directional selection, in the same area where the seed was collected (FAO *et al.*, 2004b). In Europe, most national conservation strategies for forest genetic resources are based on a dynamic approach. Dynamic conservation of genetic diversity is defined as *in situ* or *ex situ* aimed at conserving evolutionary processes and adaptive potential of natural or hand-made tree populations across generations (Koskela *et al.*, 2013).

The EUFGIS (European Information System on Forest Genetic Resources) project (April 2007-March 2011) created an online information system for forest genetic resources (FGR) inventories in Europe to support the countries in their efforts to implement FGR conservation as part of sustainable forest management (http://www.eufgis.org/). This database is focused on improving documentation and management of dynamic conservation units of forest trees. Presently, the EUFGIS database contains a total of 3595 conservation units for 108 tree species from 35 countries. The units harbor a total of 4318 populations.

6.1 State and approaches used for *in situ* conservation in Portugal.

In Portugal, the main objectives of *in situ* gene conservation and management units are to create good conditions for future evolution in response to changes in its environment, to conserve specific adaptive in marginal populations and to save endangered populations.

In this chapter we have included two *in situ* forest managed areas unit types: *in situ* genetic conservation units considering dynamic conservation approach (Table 6.1) and *in situ* certified seed production units (identified and selected category) for forest reproductive material (FRM) production (Table 6.2). Both unit's types are registered regardless its forest ownership is public or private.

Regarding these *in situ* dynamic GCI, from a total of 28 units for eleven species, only nine units for seven species are registered in EUFGIS Portal (INIAV and ICNF, 2018). Those units were identified between 1994 and 2014, but 2000-2014 were the last years that some of them were visited.

Table 6.1. Portuguese *in situ* forest genetic conservation units.

Target Species	Location	Type and Function of the units	Number of conservation units		Area (hectares)	
			Total	EUFGIS Portal (*)	Total	EUFGIS Portal (*)
Arbutus unedo (***)	Different locations	Anthropogenic threat	6	-	Few	-
Arbutus unedo	Penamacor	Biodiversity	1	-	2	-
Fraxinus angustifolia; Populus nigra	Alter do Chão	Protective forest area	1	PRT00001	10.1	10.1
Juniperus phoenicea (***)	Vila Nova de Mil Fontes	Anthropogenic threat	1	-	Few	-
Juniperus oxycedrus (***)	Peniche	Biodiversity	1	PRT00010	100	100
Pinus sylvestris	Gerês	Biodiversity	1	PRT00009	193	193
Pinus sylvestris (****)		Refuges	2	-	19.5	-
Populus alba	Tavira	Rare species	1	PRT00006	0.5	0.5
Quercus ilex; Quercus suber	Barrancos	Biodiversity; Protective forest area	1	PRT00003	30	30
Quercus suber (**) (***)	Montalegre Tavira Mirandela Queluz	Biodiversity; Managed for cork production	13	PRT00002 PRT00004 PRT00007 PRT00008	3164	84 50 3000 30
Total			28	9	-	3497.6

(*) http://portal.eufgis.org/search/simple/list/
(**) Varela and Eriksson (1995)
(***) INIAV and ICNF (2018)
(****) Pavia *et al.* (2014)

For Scots pine (*Pinus sylvestris*) besides the one registered in EUFGIS database, two other Portuguese populations were identified but not registered yet. The existence of these Portuguese populations was documented at the beginning of the XX century, and before plantations with allochthonous material. These two nuclei occupy approximately a total area of 19.47 ha. The largest, "Ribeira da Biduiça" with 14.44 ha, grows in high altitude (close to 1000 meters) and has difficult access, which leads to a low human action (Fernandes *et al*., 2015). These two populations have high biogeographic and biogenetic interest, as they are the only autochthonous populations known in Portugal and the western limit of the natural distribution of this species. Genetic diversity was assessed by the cpSSR and nSSR markers and compared to four foreign Scots pine populations representative of the species distribution in Europe. The pool of the nSSR and cpSSR data supported the belief that these two Portuguese *P. sylvestris* populations are native and could be considered nuclei remnants of a glacial refugee (Pavia *et al*., 2014).

During a phenotypical survey, in 2018, a strawberry tree (*Arbutus unedo*) population was identified as *in situ* conservation unit. This population is characterized by high plants (6 to 9 meters) constituting a stand dominant stratum. The area, near Penamacor, is an interior region with high hydric stress and an organic layer of leaves quite relevant.

Table 6.2. Portuguese approved source-identified and selected category basic material units for certified forest reproductive material production.

Tree species		Number of Units	Area (ha)
Scientific Name	**Common Name**		
Abies alba	European Silver Fir	1	0.30
Abies pinsapo	Spanish Fir	1	1.00
Acer pseudoplatanus	Sycamore	3	1.50
Alnus glutinosa	Common Alder	2	1.80
Betula pubescens	Silver Birch	3	3.82
Castanea sativa	Sweet Chestnut	14	33.71
Cedrus atlantica	Atlas Cedar	3	3.85
Cedrus libani	Cedar of Lebanon	1	1.00
Fagus sylvatica	Common Beech	3	18.12
Fraxinus angustifolia	Narrow-leaved Ash	4	5.12
Larix decidua	European Larch	1	1.00
Picea sitchensis	Sitka Spruce	1	0.54
Pinus halepensis	Aleppo Pine	1	12.28
Pinus nigra	Black Pine	5	31.58
Pinus pinaster	Maritime Pine	25	661.88
Pinus pinea	Mediterranean Stone Pine	36	2893.27
Pinus sylvestris	Scots Pine	6	55.58
Prunus avium	Wild Cherry	2	0.80
Pseudotsuga menziesii	Douglas Fir	8	39.99
Quercus ilex	Holm oak	24	1775.37
Quercus robur	English Oak	11	569.97
Quercus rubra	American Red Oak	7	21.25
Quercus suber	Cork Oak	100	11830.35
Total		**262**	**17964.07**

Source: ICNF

Table 6.2 lists the Portuguese *in situ* forest GCI for certified seed production by species, type and function, number, and respective area. These units are registered and annually visited to evaluate their phytosanitary state.

Regarding individual trees *in situ*, the monumental chestnut trees scattered in the “Montesinho” Natural Park and “Montesinho-Nogueira” Site of Community Importance (SCI), defined in the European Commission Habitats Directive (92/43/EEC), and the “Montesinho-Nogueira” Special Protection Zone (code - PTCON0002) of the Natura 2000 network must be referred. It is necessary to implement an inventory program to identify and preserve those specimens with unique characteristics *in situ*. Notable chestnut stands (stands ≥60 years and with a minimum of 25 chestnut trees/ha) of a large size and vigour are supported for conservation by agro-environmental areas - Integrated Territorial Intervention "Montesinho-Nogueira" (code - PTCON0002). Notable chestnut stands and monumental centenary trees are sustainable ecosystems that still preserves nuts productions and play an important role in biodiversity and support for the reproduction and shelter of species of wild fauna. The notable "Montesinho-Nogueira soutos" (Site of Community Importance (SCI)) are not registered as *in situ* conservation units but they should be. Those plots are included in agro-environmental support systems to help farmers with a commitment to use management practices that preserves these multifunctional chestnut systems. The notable stands "soutos" of *Castanea sativa* provide goods and services of both ecological and economic importance. Economically, they are part of an entire rural economy associated with its main products, wood and fruit and ecologically, they have landscape value and protection of soil against erosion. There are a lack of data and studies concerning the ecology of chestnut in relation to its conservation status. Research can provide important information on the degradation of these types of habitat and improve the diagnostic protocols and measures for protection.

For maritime pine, around 500 trees are georeferenced in a private forest area "Herdade da Comporta" for their resistance to the Pine Wilt Disease (PWD) and have also to be included in a national database (Ribeiro et al., 2012; Carrasquinho et al, 2018).

6.2 Organization of *in situ* conservation efforts at national level

At national level, there is no official structure organized. INIAV and ICNF has been the two players for the forest genetic resources conservation. INIAV is responsible for the identification and registration of *in situ* conservation units on EUFGIS Portal. All the public *in situ* units for certified seed production are managed by ICNF.

In 2020, Portugal has approved five research projects aiming to the identification and management of *in situ* conservation units for some forest species, such as, maritime pine (*Pinus pinaster* Aiton), Mediterranean stone pine (*Pinus pinea* L.), cork oak (*Quercus suber* L.), Portuguese crowberry (*Corema album*) and Western prickly juniper (*Juniperus oxycedrus* L.). These projects will contribute to organize *in situ* conservation units.

6.3 Needs and priorities.

There is a clear need to improve *in situ* conservation of forest genetic resources in Portugal. To implement this aim, it is important:

- to establish forest genetic resources conservation priorities.

- to promote surveys and inventories under a national cooperation and coordination.
- to characterize and evaluate *in situ* populations already identified.
- to increase research.

Chapter 7. *Ex situ* conservation of forest genetic resources

Isabel Carrasquinho[(1)]

[(1)] INIAV I.P.

Ex situ conservation of forest tree genetic resources is mainly concerned with sampling and maintaining, as much as possible, of the genetic variation that resides within and among populations of selected target species. *Ex situ* conservation requires substantial levels of human intervention, in form either of simple seed collections, storage and field plantings or of more intensive plant breeding and improvement approaches (FAO *et al.*, 2004a).

7.1 State and approaches used for *ex situ* conservation in Portugal.

In Portugal, *ex situ* conservation of forest genetic resources includes stands; genetic trials, such as: progeny, provenances, and clonal tests; clonal archives and seed orchards; arboreta; botanic gardens; seed banks. *Ex situ* conservation activities have been carried out mainly under the following objectives: genetic improvement programs, seed trade, and endangered species.

Concerning *ex situ* stands (Table 7.1), for *Pinus sylvestris*, some activities, such as seed collection, production of plants and subsequent afforestation of new areas were initiated, linking *in situ* to *ex situ* conservation. These actions aim to preserve the genetic heritage from the two autochthonous populations ("Biduíça" and "Matança") known to be the western limit of the natural distribution of this species (see chapter 6).

Table 7.1. *Ex situ* conservation stands for *Pinus sylvestris* and *Arbutus unedo.*

Species	Stands		
	Year	Area (ha)	N Stands
Pinus sylvestris	2015	7.8	1
Pinus sylvestris	2016	6.7	1
Pinus sylvestris + Quercus pyrenaica	2017	20.7	1
Pinus sylvestris	2018	18.10	5
Pinus sylvestris	2019	5.2	2
Pinus sylvestris	2020	10.1	7
Arbutus unedo	2020	1.1	2

Genetic field trials (provenance, progeny, and clonal tests) are mostly for the economical species, such as maritime pine, cork oak, Mediterranean stone pine, and eucalyptus (Table 7.2). All the maritime pine progeny tests are constituted by half-sib families. For this species, a clonal test focused to study genetic variation in resin yield, using 50 clones, was initiated in 2021 under a recent approved project.

Table 7.2. Long-term genetic trials for *Pinus pinaster*, *P. pinea*, *Quercus suber* and *Eucalyptus globulus*.

Species	Provenance tests				Progeny tests				Clonal tests			
	Year	Area (ha)	N trials	N provenances	Year	Area (ha)	N trials	N families	Year	Area (ha)	N trials	N clones
Pinus pinaster Ait.	1993	9	2	30	1987	2.0	1	46	2021	7	1	50
	-	-	-	-	1994	2.2	1	100	-	-	-	-
	-	-	-	-	1988	0.6	1	46	-	-	-	-
Pinus pinea L	1993	3.8	1	25	-	-	-	-	-	-	-	-
	1998	3.5	1	30	-	-	-	-	-	-	-	-
	2010	2	1	23	-	-	-	-	-	-	-	-
Quercus suber	1998	12	1	35	1998	11	2	22	-	-	-	-
Eucalyptus globulus	2015	3	3	4	2009	11	2	270	2007	35	17	1500

Due to the Dutch Elm Disease, *in situ* conservation is no longer possible for *Ulmus minor* species. Therefore, since 1999, 40 Portuguese and three Italian genotypes are being conserved in a clonal bank at ENF, using cuttings propagation. This clonal bank was established under the European Project, RESGEN CT 96-78 “Conservation of Elm genetic Resources”. Annually, those clones are pruned to guaranty their survival (Table 7.3).

Table 7.3. Clonal banks and seed orchards for forest genetic species

Species		Native (N) /exotic (E)	Seed orchards				Clonal Banks		
			Year	Area (ha)	Type	N clones/ families	Year	Area (ha)	N clones
Pinus pinaster	Escaroupim	N	1970	15.5	clonal	60	2000	2	43
Pinus pinea	Coruche	N	-	-	-	-	2004	8	64
Quercus suber	Escaroupim	N	-	-	-	-	1998	0.03	12
Ulmus minor	Escaroupim	N	-	-	-	-	1999	0.03	43
Castanea sp.	Bragança	N/E	-	-	-	-	1950	1	50
Castanea sp.	Amarante	N/E	-	-	-	-	1994	0.25	20
Castanea sp	Marvão	N/E	-	-	-	-	2015	0.5	4
Arbutus unedo	Coimbra	N	2015	0.25	clonal	45	-	-	-
Populus nigra	Coimbra	N	-	-	-	-	2003	0.5	18

In the fifties, interspecific hybridizations between *Castanea sativa, C. mollissima* and *C. crenata* were initiated to identify resistant plants to *Phytophthora cinnamomi*. The breeding resistant material resulting from those hybridizations and from recurrent selection and phenotypic resistant *C. sativa* were maintained as a collection of resistant clones in the IPB arboretum, in Bragança, with an area of approximately one hectare. The initial clonal collection of 50 clones needs at present to be renewed and updated. Recently, in 2015, controlled crosses between European and Japanese chestnuts were performed and two full-sibs progenies created (Santos *et al*. 2017). Those hybrid collections are represented in different clonal banks, such as "Amarante", "Bragança" "Marvão", and "Vila Real" campus (Table 7.3). At "Marvão", about 30 ramets from each of four phenotypically selected plants for resistance to *P. cinnamomic* were planted. Those ramets were obtained by micropropagation. Information from "Vila Real" clones was included in the Plant Genetic Resources report.

In 2015, a strawberry tree (*Arbutus unedo*) clonal seed orchard with 45 micropropagated plus trees was established in ESAC at "Coimbra" campus. Those plus trees were selected for their fruit production and quality in this species distribution area (Araújo *et al.*, 2021).

In 1933, an experimental field with oaks and related genera was established at "Vimeiro" National Forest (VNF), Portugal (Table 7.4). This experimental area includes the only Portuguese plots with the hybrid *Quercus* x *hispanica* hybrid 'Lucombeana' (*Quercus cerris* x *suber*) with seeds obtained from the Cambridge Botanic Gardens. Between 1962 and 1965, their offspring were included in this area. Those plots represent a unique population for understanding the structure, function, and evolution of the genome (genomics) and its gene expression (transcriptomics) (Meireles *et al*., 2018). In all progenies, with approximately 60 years, it is evident the segregation for several phenotypic characteristics, specifically in the cork formation and in the leaf shape (Carrasquinho *et al.*, 2020).

Table 7.4. Arboreta

Collection Identification	Localization	Species	Area (ha)	Year	N Accessions
S. Francisco arboretum	Aveiro-Eixo	*Eucalyptus sp*	4	1902	80 species
Quercus sp. Hybrids (*)	VNF	*Quercus x hispânica* ´Lucombeana´ *(Quercus cerris* x *suber)*	2.4	1933	12 mother trees; 85 half sibs
Eucalyptus arboretum	ENF	*Eucalyptus sp*	26	1953	110 species
Monoclonal collection	VNF	*Quercus suber*	0.5	1970	1
Castanea sp. hybrids	Coimbra	*Castanea sativa* x *crenata*	0.5	2005	37 full sibs (1 cross)
Castanea sp. hybrids	Coimbra	*Castanea sativa* x *mollissima*	0.5	2005	15 full sibs (1 cross)
REINFFORCE arboreta (**)	Lisbon, Vila Real, Sintra	33 forest species	9.0	2012	3 provenances/species; 12 trees/ provenance

(*) Carrasquinho *et al.* (2020)
(**) http://www.iefc.net/newsite/sitereinfforce/arboretum-demonstration-site-catalogue/

Two major historic eucalyptus arboreta in Portugal, "Quinta de São Francisco" and "Escaroupim" National Forest (ENF) were established in 1902 and 1953, respectively. The ENF arboretum includes a total of 110 *eucalyptus* species, 92 of which are economically important.

In 2012, six REINFFORCE arboreta from a network of 38 international arboreta, distributed between latitudes 37^0 and 57^0 N, were established in Portugal (Correia *et al.*, 2018). The aim was to identify the species most tolerant to climate variations, as well as those whose growth and survival may be limited by future climatic conditions. This network includes 33 species represented, at least, by three provenances.

Table 7.5. Main Portuguese botanical gardens

Botanic gardens	Year	Area (ha)	N Species	Observations
Lisbon (Ajuda)	1768	3.5	>1000	https://www.isa.ulisboa.pt/en/visitors/ajuda-botanical-garden
Coimbra	1772	> 13		https://www.uc.pt/jardimbotanico/en
Lisbon	1873		1500	https://www.ulisboa.pt/patrimonio/jardim-botanico-de-lisboa
Lisbon (Belem)	1906	7	600	https://www.ulisboa.pt/patrimonio/jardim-botanico-tropical
Oporto	1951	4.0		https://jardimbotanico.up.pt/
Madeira Island	1960	3.5	>2000	https://www.madeira-web.com/en/places/funchal/gardens-parks/botanical-garden.html
Azores (Faial)	1986	8		http://siaram.azores.gov.pt/centros-interpretacao/JardimBotanico-Faial/_intro.html

There are several botanical gardens in Portugal containing native and exotic species, although those gardens have a small number of individuals for each species. Table 7.5 indicates some of them. The largest botanical garden is situated at Coimbra University with more than 13 hectares and was established in 1772. Collections included in arboreta and botanical garden contribute to the maintenance of unique and rare genotypes.

Table 7.6 Accessions of forest tree species seeds stored at ICNF/CENASEF seed bank.

Species	Number of accessions	Species	Number of accessions
Acer campestris	1	*Phillyrea latifolia*	1
Acer monspessulanum	1	*Picea sitchensis*	1
Catalpa bignonioides	1	*Pinus nigra*	1
Cercis siliquastrum	1	*Pinus pinaster*	5
Chamaecyparis lawsoniana	1	*Pistacia terebinthus*	1
Crataegus monogyna	1	*Platanus acerifolia*	1
Cryptmomeria japonica	1	*Prunus avium*	1
Cupressus lusitanica	1	*Prunus serotina*	1
Cupressus sempervirens	1	*Pseudotsuga menziesii*	1
Frangula alnus	1	*Pyracantha angustifolia*	1
Ginkgo biloba	1	*Sorbus aria*	1
Ilex aquifolium	1	*Sorbus aucuparia*	1
Juniperus oxycedrus	1	*Sorbus torminalis*	1
Ligustrum vulgare	1	*Tilia tomentosa*	1
Liquidambar styraciflua	1	*Ulex europaeus*	1
Magnolia grandiflora	1	*Ulmus minor*	1
Melia azedarach	1	*Viburnum tinus*	1

ICNF/CENASEF is the main institution responsible for harvest, storage, and trade of conifer seeds and non-recalcitrant hardwood species for the forest sector. Table 7.6 indicates the list of forest species included in this seed bank.

7.2 Organization of *ex situ* conservation efforts at national level

Most of *ex situ* conservation field public collection are established in areas under ICNF management. INIAV is the institution responsible for breeding activities research and respective field trials. Concerning the eucalyptus, private companies (viz THE NAVIGATORCOMPANY and ALTRI FLORESTAL) run their own collections.

For each collection, there is available genetic information, and their records are kept in databases at the institution's owners.

7.3 Needs and research priorities.

The needs and priorities for *ex situ* conservation of forest genetic resources in Portugal include management of *ex situ* collections and research activities:

- Increase institutional capacity

- Obtain funding for maintenance of collections
- Enlarge seed and field collections
- Update and organize collections data
- Promote back-up samples (seeds or vegetative material) conservation of threatened species
- Promote the seed conservation from seed orchards to monitor genetic diversity.
- Develop suitable conservation methods for each tree species.

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

Chapter 8. The state of use

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8.1 State of forest genetic resources use in Portugal.

The use of forest genetic resources (FGR) in Portugal is regulated and overseen by National (DL 13/2019 of January 21) and European Community legislation (Directive 1999/105/EC of December 22). For 48 forest species, the forest reproductive material (FRM) must be traced back to its origin. Portugal operates with 24 species from the 48 listed in the European Directive. For those 24 species, the stands for collecting FRM are listed in the National Register of Basic Material (NRBM) and in the FOREMATIS (Forest Material Information System) European database. Portugal is generating a national database for the other species that are not registered in NRBM.

All the stakeholders involved in the use of FGR at a commercial level are also registered in a database and their transactions are documented. This program is supervised by the National Forestry Authority, ICNF. Seeds and plants of those species, to be used in plantations over 0.5 hectares, are certified, and forestry projects must be subject to ICNF for evaluation. These obligations are framed by national legislation and community directives and seek to foster sustainable and multifunctional forest management.

FRM producers and suppliers are systematically monitored, either in inspection actions or in technical support, to fulfil the objectives emanating from the legislation in force. The market for selling FRM is regulated and adapted to forest owner needs.

In Portugal, FRM imports/exports are residual regarding to the number of produced plants in the country and supplied to forest owners. FRM produced and marketed in Portugal are subject to legislation, as mentioned, excepted to those that are not intended for forestry purposes such as for research activities. The existing rules guarantee the classification of FRM according to the Basic Material (BM) from which they are originated and characterized.

For each species, plants can only be marketed unless 95 % of each lot has no apparent damages, is well-shaped and with a size and age established by the current legislation. This framework is in accordance with the objectives of genetic improvement and conservation of forest resources and guarantees the quality of woody material. In this sense, regions of provenance were defined where the BM show adequate productivity and adaptability to soil and climate conditions guaranteeing the genetic variability of each species. This work has been carried out for many years and has contributed to generate high economic gains. Pine nuts, cork, wood for pulp productions are particularly important assets in the Portuguese trade balance.

The average production of plants in Portugal considering the last three years (2017 – 2020) is presented in Tables 8.1 and 8.2.

Table 8.1. List of the Portuguese average number of plants produced by species regulated by EU and National legislation in the last three years (2017-2020).

Species	Number of plants produced
Abies alba	6 527
Acer pseudoplatanus	20 749
Alnus glutinosa	87 738
Betula pendula	5 000
Betula pubescens	96 722
Castanea sativa	208 605
Cedrus atlantica	12 414
Eucalyptus globulus	25 736 548
Fagus sylvatica	22 232
Fraxinus angustifolia	173 376
Fraxinus excelsior	2 694
Pinus nigra	179 644
Pinus pinaster	2 105 831
Pinus pinea	1 346 334
Pinus radiata	947 171
Pinus sylvestris	332 031
Prunus avium	30 303
Pseudotsuga menziesii	98 651
Quercus ilex	326 060
Quercus robur	232 137
Quercus rubra	432 068
Quercus suber	1 200 759

8.2 Needs and priorities

Concerning the needs and priorities, it is important:

- Finnish database for the species not included in RNMB but used in forestry.
- Identify new populations for forest genetic conservation to increase the FRM supply to face the risks associated to forest fires, emerging pests, and climate changes.

- Continue to invest in knowledge and in its application to enlarge the capacity to reproduce native and threatened species, to create new healthy forests areas better adapted to climate change to promote the quality of the landscape.

Table 8.2. List of the Portuguese average number of plants produced by species and regulated by National legislation in the last three years (2017-2020).

Species	Number of plants produced
Acer monspessulanum	1 133
Arbutus unedo	876 382
Casuarina equisetifolia	46 850
Celtis australis	13 561
Ceratonia siliqua	17 308
Cercis siliquastrum	167
Corylus avellana	293
Crataegus monogyna	6 535
Cryptomeria japonica	100
Cupressus lusitanica	316 691
Cupressus macrocarpa	8 050
Cupressus sempervirens	87 646
Eucalyptus nitens	1 221 623
Eucalyptus spp	1 843 997
Frangula almus	4 535
Ilex aquifolium	5 223
Jasminum fruticans	115
Juglans nigra	36 548
Juglans regia	2 390
Juniperus oxycedrus	293
Juniperus turbinata	696
Laurus nobilis	1 325
Myrtus communis	1 453
Phillyrea angustifolia	5 429
Phillyrea latifolia	1 040
Platanus spp	46 361
Populus spp	613
Prunus lusitanica	6 920
Prunus spinosa	265
Pyrus bourgaeana	148
Quercus canariensis	1 735
Quercus coccifera	5 077
Quercus coccinea	6 987
Quercus faginea	66 331
Quercus pyrenaica	202 025
Salix alba	7 221
Salix atrocinerea	9 114
Salix babylonica	200
Sambucus nigra	3 129

Species	Number of plants produced
Sorbus aucuparia	534
Sorbus latifolia	1 025
Taxus baccata	19 180
Ulmus minor	1 471
Viburnum tinus	3 064

Source: ICNF

Chapter 9. The state of genetic improvement and breeding programs

Isabel Carrasquinho [(1)], Nuno Borralho [(2)] and Filomena Gomes [(3)]
[(1)] INIAV; [(2)] The Navigator Company; [(3)] ESAC

In Portugal, INIAV is the national institution responsible for the genetic improvement programmes of the following forest species: maritime pine, cork oak, Mediterranean stone pine, and chestnut. Universities, such as ISA-UL and UTAD, and other institutions, ICNF, DRAP, have contributed for the establishment, evaluation and/or the management of the genetic field trials or other breeding activities. ESAC is developing the breeding program of strawberry tree. Concerning the *Eucaliptus globulus* two independent breeding programmes have been developed by two private companies, RAIZ (part of THE NAVIGATOR COMPANY) and ALTRI FLORESTAL.

Maritime pine (*Pinus pinaster* Aiton) plus tree selection for volume and stem conformation, traditionally one of this species caveats, started in the mid 1960's at LNF. Sixty plus trees were kept as grafts in seed orchards and in a clonal bank (Table 7.2). An official tree improvement programme was developed in the early 80s (Roulund *et al.*, 1988). Later, those plus trees were genetically evaluated based on the EBLUP methodology, and a new clonal seed orchard was established in 2000 (Aguiar *et al.*, 2003). Three other mass selection programmes give rise to a multiple population breeding system constituted by four different breeding populations. However, after the 2017's forest fires part of these breeding populations was lost.

In 2009, about five hundred healthy adult maritime pine trees were phenotypically selected, as resistant to pine wilt disease (PWD). They were identified in an area highly affected by PWD. Pinewood nematode (*Bursaphelenchus xylophilus* (Steiner et Buhren) Nickle) is the causal agent of PWD. For assessing genetic variation in maritime pine to PWD, a greenhouse progeny test permitted to identify fifteen out of 96 half-sib families as genetically less susceptible to this disease using quantitative genetics methodology (Carrasquinho *et al.*, 2018).

An international network for cork oak (*Quercus suber*) provenance and progeny trials was established in 1998 within the framework of the Concerted Action project FAIR CT 95-202 (EUfunds) "European network for the evaluation of genetic resources of cork oak for appropriate use in breeding and gene conservation strategies" (Varela, 2003). In the provenance trials, 35 populations represent the entire species' natural distribution, whereas the two progeny trials contain 22 open-pollinated families per population (4 to 5) under test. Those genetic field trials were carried out on a harmonized methodological basis at the level of the plants used and, in the field, the same experimental device was applied. They constitute an important genetic material for studying sustainable management of the cork oak tree, adaptation to global changes, genetic flows, phytosanitary problems, quality of cork and will permit to establish a breeding and conservation strategy for the species. Quantitative (based on EBLUPs methodology) and molecular characterization (SNPs, cpDNA, EST and genotyping sequencing) were performed in the provenance trials (Pereira-Leal *et al.*, 2014). These methodologies showed significant genetic variation for both adaptative (Sampaio *et al.,* 2016, Sampaio *et al.*, 2019) and neutral traits (Costa *et al.*, 2011; Modesto *et al.*, 2014; Pina-Martins *et al.*, 2019). Genetic variability among and within-populations was detected for survival, growth, and form traits. Cork oak populations differed significantly in the timing of budburst, affecting their exposure to pest activity. Additionally, growth traits and spring shoot phenology are under high genetic control (Sampaio *et al.*, 2021).

In 1992, twenty-five seed lots from seven different countries were obtained with the cooperation of the Silva Mediterranea network for the establishment of the Mediterranean stone pine (*Pinus pinea* L.) provenance trial. Based on linear mixed spatial models, provenance genetic variability was detected for survival and height at different planting ages and for diameter at breast height at age 13 after planting. When multi-environmental analysis was performed, provenance x site interaction variability was detected for survival. The existence of provenance variability permitted the identification of a seed lot composed of a mixture of the best provenances for height and diameter that could be used for future plantings (Carrasquinho *et al.*, 2013). Later, in 1998 and 2010, two other provenance trials were established with 30 and 23 different provenances, respectively. The genetic diversity of *Pinus pinea L.* was also evaluated using molecular markers (Evaristo *et al*., 2002).

Increasing kernel production, both in quantity and in quality, is one of the main purposes of the *Pinus pinea* L. Portuguese improvement program. About a hundred plus trees have been phenotypically selected in Portugal and some of them (64) were grafted to a clonal bank to produce certified forest reproductive material (stems for grafting). A methodology to identify plus trees with high kernel production, using permanent plots, was established (Carrasquinho *et al.*, 2010).

The production of new hybrid varieties with improved resistance to *Phytophthora cinnamomi,* the causal agent of ink disease, has been the main breeding method to integrate resistance into the European chestnut (*Castanea sativa* Miller). The aims are to obtain new rootstocks for grafting and to create new resistant varieties (Santos, 2017). Transcriptomic and genomic studies have provided new insights underlying the mechanisms of resistance by studying genotypes of chestnut hybrid species with different phenotypic susceptibilities to the pathogen (*Castanea sativa x crenata* and *C. sativa x mollissima*) (Fernandes *et al.*, 2020).

Since 2005, a phenotypic selection for fruit production and quality was performed in *Arbutus unedo* distribution area. About 200 plus trees were selected and georeferenced. Fifty percent of those plants were identified in protected areas or in the Natura 2000 Network. Some of the wild plants were also selected by producers for high fruit production. After, those plants were morphological, chemical, and genetic (genomic) characterized. Forty five of those plus trees were micropropagated to a clonal seed orchard using a proper experimental design. Some trials were established to evaluate genotype environment interaction.

In Portugal, there are two independent eucalyptus (*Eucalyptus globulus)* breeding programmes in place. Both are originated from ancestors (or base parents) of two broad origins: (i) from known mother trees selected in native stands in Australia (henceforth of assigned native races; Freeman *et al*., 2007) and (ii) from plus trees selected in local stands in Portugal (of unknown ancestral origins). One of the programs (ALTRI FLORESTAL) is on its 3rd discrete generation, and it is a two-tier breeding scheme with an elite population and a broader base population. The RAIZ program is in its 4th cycle and it is an overlapping-generation (or "rolling-front") scheme with a sub-set of families being tested already as clones (Araujo *et al*., 1997).

Both programs rely on a multivariate EBLUP selection scheme, which incorporates information from growth, survival, wood density and pulp yield, from a total of up to 269 trials (185 from RAIZ and 84 from ALTRI), located across the whole range of climate and soil conditions in Portugal. A joint EBLUP analysis of the two programs was completed recently (Borralho *et al*. 2018). Secondary selection traits include resistance to major pests and diseases and rooting ability. Molecular studies have been carried out over time, although no formal marker-based selection is yet in place. Regular fingerprinting of genetic stocks is used, for quality control (Ribeiro *et al.*, 2010) and genetic diversity studies (Costa *et al*., 2017). Emerging technologies include the validation and adoption of a Genome Wide Selection protocols based on specific microarray chips (recently developed for eucalyptus). Major challenges remain in improving selection accuracy against biotic and abiotic stresses and overcoming poor propagation ability of the species.

White crowberry (*Corema album* L. D. Don) is included in the endemic forest shrub list. It appears in the Iberian Peninsula Atlantic coast dunes (Carapeto *et al.*, 2021). White color and sweetness fruits present high nutritional value and important antioxidants. In 2015, along the *C. album* natural habitat, a phenotypic selection of the best genotypes started a breeding program. Eight criteria were established for plant selection: fruit production (number of fruits per plant), fruit size, fruit shape, easy fruit harvest, fruit ripening homogeneity, color (white color intensity), taste (in loco evaluation) and plant vigor. Twenty plants were selected and georeferenced in ten different sampled sites. Fruits and cuttings were collected, and their morphological, physical, and chemical properties were analyzed (Jacinto *et al.*, 2021). Genetic diversity based on inter-simple sequence repeats (ISSR) was assessed using seventy-one female plants, from four different sites (Jacinto *et al.*, 2020).

In the Table 9.1 it is indicated the forest species involved in improvement genetic programs in Portugal and their respective objectives.

Table 9.1. Forest improvement programs in Portugal

Species	Native (N) or Exotic (E)	Improvement programme objective
Pinus pinaster	N	Timber
Pinus pinaster	N	Resistance to *Bursaphelenchus xylophilus*
Quercus suber	N	Cork production
Pinus pinea		Cone/kernel production
Castanea spp (C. sativa x crenata; C. sativa x mollissima)	E	Rootstocks resistance to *Phytophthora cinnamomi*
Eucaliptus globulus	E	Pulp production
Arbutus unedo	N	Fruit production and quality
Corema album	N	Fruit production and quality

9.2 Needs and research priorities

- Combine molecular tools with forest genetic tree improvement for testing paternity contributions to offspring.
- Develop and reinforce genetic tree improvement for most important forest species in the country, particularly for economical traits, resistance to pest or diseases and climate changes such as drought.

Chapter 10. Management of forest genetic resources

Helena Marques [1]

[1] ICNF

The use of high quality reproductive forest material is highly recommended for planted forests and regulated by national legislation, as it was described in the chapter 8.

As a result of climate change, reshapes in the current distribution areas for some species may occur, as well as an increased risk of desertification. In Portugal, climatic changes will be reflected by an increase in temperature, solar radiation and frequency and intensity of extreme events and a decrease in precipitation and relative humidity. Some forest species may suffer accentuated mortality in drier limit of its current distribution area. The forecasts pointed to the reduction of the suitable areas for *Pinus pinaster* and *Eucalyptus spp.*, in the south of the country, for cork oak in the south and interior center. However, for this latter species it can be expected an increase of its potential distribution area in the interior north of Portugal. The regression of the potential distribution area of the cork oak in the most arid regions in the south may be accompanied by its replacement of holm oak, in the most favorable situations, or by xerophyte shrub formations.

Forest fires are a pressure with a significant impact in fauna, flora, and natural habitats. Regarding forest stands, the greatest impact of fires in the last two decades has been on *Pinus pinaster* and eucalyptus stands, which is associated to high reductions in wood production for these two species.

Some phytosanitary problems have been identified in the Portuguese forests, affecting the main forest systems, some of them associated with disturbances caused by various biotic and abiotic factors and others associated with the type of forest management that has been implemented.

In the mainland, “montado”, pines, eucalyptus forest and other forest essences, such as: chestnut and other oaks have been the forest systems most affected by phytosanitary problems. In Azores Autonomous Region *Cryptomeria japonica* has also been disturbed.

To cope with those negative pressures, the Portuguese national forest strategy sets as a priority the enhance of the value for forest genetic resources. However, specific measures have to be implemented, such as: increase the number of forest conservation units by supporting inventories and respective characterization, promote the development of genetic improvement programs, assure to use in afforestation appropriate genetic material.

Part 5: State of capacities and polices

Chapter 11. Institutional framework for the conservation, use and development of forest genetic resources

Isabel Carrasquinho [1] Helena Marques [2]

[1] INIAV; [2] ICNF

As defined by Decree-Law No. 69/2012 of March 20 and by legal determination No. 392/2012 of November 29, INIAV is the public institution responsible for promoting the conservation of national genetic resources in the animal and vegetal areas. ICNF, the National Forest Authority, is the official body that promotes FRM certification and ensures its genetic quality for the most used species in afforestation. Production of FRM activities is done in close collaboration with all stakeholders.

From a global point of view, Portugal updated the national strategy for forests including the use of improved plants as a tactical line to ensure and increase the economic production of stands. However, there is no specific legislation focused on genetic conservation of forest genetic resources except the one related to the marketing of forest reproductive material (Decree Law No. 13/2019 of January 21) already described on chapter 8.

At the end of 2019, the FAO National Focal Point (NFP) on forest genetic resources for Portugal was nominated under INIAV proposal. Portugal has not yet established a national program for the conservation of forest genetic resources but various efforts in this regard have been carried out. Cork oak (*Quercus suber*), representing widely distributed tree species, was the first species for which gene conservation efforts were started. Eleven stands, mainly *in situ* populations, were proposed as gene reserve forests in 1994. Informally, INIAV and ICNF have been the two public institutions dealing with forest genetic resources focusing on research and management activities, respectively. At a public level, PROGEN, an operational program for the conservation and improvement of forest genetic resources was developed (INIAV and ICNF, 2018). This document was the basis to support, at a national level, the financing of projects aimed at genetic improvement and conservation of forest resources. The first five projects focused on these issues were approved in 2020.

Conservation of forest genetic resources is part of the curriculum of the forestry courses at universities and colleges. At Lisbon University (ISA/UL), topics such as: species extinction risk; objectives and needs for genetic resources conservation; *in-situ* and *ex-situ* conservation methodologies are covered in "Forest Genetic Improvement" discipline.

National Institutions and policies must be strengthened to implement sustainable use, development, management, and conservation of forest genetic resources in Portugal. Increasing research and education are the key to build national capacity to plan and implement priority activities of FGR. Integrating FGR needs into wider national policies constitutes other important aspect. Promoting collaboration and networking among institutions for obtaining and sharing information on the status, trends, and characteristics of FGR are needed to identify priorities for direct actions. All those actions are essential to develop a national strategy for FGR.

Chapter 12. international and regional cooperation on forest genetic resources

Isabel Carrasquinho [1]

[1] INIAV

Portugal is a signatory of FOREST EUROPE (Ministerial Conference on the Protection of Forests in Europe). It is the Pan-European voluntary high-level political process for intergovernmental dialogue and cooperation on forest policies in Europe. FOREST EUROPE has led to achievements such as the internationally agreed guidelines, criteria, and indicators for sustainable forest management. With the aim of agreeing on how to manage forests in Europe, the FOREST EUROPE process periodically hosts ministerial level conferences where ministerial commitments and resolutions are adopted. By endorsing the declarations, decisions and resolutions at the FOREST EUROPE platform, the signatories make clear political commitments to protect and sustainably manage their forests. Commitments endorsed by the ministers serve as a framework for implementing sustainable forest management in the European countries, adapted to their national circumstances, and done in a coherent way with the rest of the region, and strengthen international cooperation at the same time.

Portugal participated in EUFORGEN until the end of phase IV, in 2009. The EUFORGEN (European Forest Genetic Resources Program) is a collaborative program among European countries with the mission to ensure and promote the conservation and sustainable use of forest genetic resources in Europe and to serve as a platform for pan-European forest collaboration. It was introduced during the second Ministerial Conference in Helsinki (1993) to implement Resolution 2 on the Conservation and Sustainable Utilization of Forest Genetic Resources, established at the first Ministerial Conference in Strasbourg (1990) dedicated to the protection of forests in Europe. EUFORGEN became operational in October 1994. Currently, the Program is in phase VI (2020-2024). At the first Ministerial Conference in Strasbourg, Portugal was one of 31 countries that committed to the creation of an international, voluntary structure that would coordinate *in situ* and *ex situ* genetic conservation, the exchange of forest reproductive material, and monitor the progress of these methodologies. Currently, Portugal is not a member of this Program.

The database EUFGIS (European Information System on Forest Genetic Resources) includes 4400 tree populations of 109 forest species, contained in 3660 genetic conservation units from 35 countries. Portugal has registered nine GCI for the following species: *Quercus suber*, *Quercus suber* and *Quercus ilex*, *Fraxinus angustifolia* and *Pinus sylvestris*, *Populus nigra*, *Populus alba,* and *Juniperus oxycedrus* (see Table 6.1). The aim of EUFGIS is the development of a European forest genetic resources information system and the identification of GCI, i.e., forest stands, or forest areas designated at the national level for the conservation of forest genetic resources.

Portugal is also a member of the OECD (Organization for Economic Co-operation and Development) Scheme for the Certification of Forest Reproductive Material which intends to encourage the production and use of forest tree seeds or plants that have been collected, processed, raised, labelled, and distributed in a manner that ensures their trueness to name. This certified material is designed for use in a variety of forestry functions, including timber production, soil protection, and environmental criteria (https://www.oecd.org/agriculture/forest/, accessed in April 27). Currently, 29 participating countries implement the Scheme. Seeds and plants are produced and officially controlled according to harmonized procedures, which reflect the growing commercial importance of new types of material derived from breeding programs, including new forestry production and tree improvement techniques. Portugal operates 24 species from the 48 listed in the European Directive. For those 24 species, the stands for collecting FRM are listed in the FOREMATIS European database. This System provides a search tool for forest breeders, forest nurserymen, experts, and the public, functioning as a repository linked with EU countries' data of planted forest tree species. FOREMATIS provides access to national registers, contains details of the approved basic material including data on areas or geographic location which is essential for determining if a particular material is suitable for a site.

Portuguese researchers have been involved in some international projects related to forest genetics resources. Between 2011 and 2017, UTAD has participated in two projects funded by the Spanish Ministry of Economy and Competitiveness, "RTA2013-00048-C03-01 - Integrated Production in Spanish Pine Forests: From the Diversity of Species to Genetic Improvement Programs (2014-2017)" and "CLONAPIN - Improvement, adaptation, and phenotypic variation of *Pinus pinaster* Aiton" (2011-2014).

The priority for Portugal strengths the international cooperation on forest genetic resources is its reintegration in the EUFORGEN Program by nominating a National Focal Point.

Part 6: Challenges and opportunities

Chapter 13. Recommended actions for the future

Isabel Carrasquinho [1]

[1] INIAV

The Global Plan of Action (GPA) for the Conservation, Sustainable Use and Development of Forest Genetic Resources of the FAO (FAO, 2014a) lists 27 strategic priorities grouped in four priority areas: (1) Improving the availability of, and access to, information on FGR; (2) Conservation on FGR (*in situ* and *ex situ*); (3) Sustainable use, development and management of FGR; (4) Policies, institutions and capacity-building.

According to GPA, some recommendations for further actions to strength the conservation, use and development of FGR in Portugal are listed below.

Therefore, for the first priority area: "Improving the availability of, and access to, information on FGR":

- Promote species inventory, characterization, and FGR databases.
- Develop protocols and documentation systems for accessing and monitoring FGR management.
- Share information at national and international level.
- Create a link between data information on FGR and the Portuguese National Inventory
- Obtain financial support for research activities.

Second priority area: "Conservation on FGR (*in situ* and *ex situ*)":

- Promote the establishment of *ex situ* conservation programs mainly for endangered species due, for example to changes in land use, environmental conditions, or biotic threats.
- Identify priority species for action, using guidelines and considering not only endangered species but also strategic and with economic importance.

Third priority area: "Sustainable use, development and management of FGR"

- Reinforce national seed program ensuring the availability of genetically appropriate and certified material to face plantation programs.
- Develop guidelines for identification, selection and use of population conservation units based on environmental sociocultural factors.
- Promote new technologies to support conservation and tree improvement programs to enhance the use of quality materials.

- Reinforce networking and collaboration among countries.

Fourth priority area: Policies, institutions and capacity-building

- Develop national strategies for *in situ* and *ex situ* conservation.
- Strength Portuguese Institutions related to FGR and promote collaborations among them.
- Promote training workshops and research activities.
- Promote international network for sharing information, research, management, and conservation.

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