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

COUNTRY REPORT

ITALY

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.

Second Report on the State of the World's Forest Genetic Resources

National Report: Italy

FGR National Focal Point
Fulvio Ducci

Foreword

The period in which we are given to live is characterized by increasing complexities and evolutions at speeds never encountered before, and it is now clear to everyone that local crises and events rapidly become planetary issues since all realities are interconnected.

Never as in recent years have trees and woods been so at the center of attention by citizens and institutions, in the common concern for the world's forests that are disappearing under the weight of economic pressures. And never has such a complex system, especially from a regulatory and competence point of view, needed coordination and sharing to face a challenge of global dimensions.

It should be noted that the diversity of its innumerable components, the plurality of interests at stake, the multiplicity of protagonists and skills involved in forest life and management necessarily converge in the unity of the forest.

The NEXT generation EU, the PNRR, the Biodiversity Strategy 2030 and the EU and Italian Forestry Strategy strongly believe in the role of forests, and make large sums available to increase their resilience, to reverse the loss of biodiversity as well as mitigate and promote their adaptation to climate change.

This is a complex challenge that deserves an equally complex response. "Planting better forests for a changing future" is not just an OECD slogan but summarizes a fundamental concept: the planting of new trees, whether it is to create urban and peri-urban forests, whether it is afforestation or restoration of degraded areas, must be carried out by planting "the right tree in the right place for the right purpose", which considers current conditions and possible future scenarios.

In fact, the European strategy not only aims to promote the planting of 3 billion trees but “defines a vision and concrete actions to increase the quantity and quality of forests in the EU and strengthen their protection, restoration and resilience. "

One of the systems to achieve this goal is the correct use of Forest Genetic Resources, but above all, their study, in-depth knowledge, and correct management; a complex management, in fact, in which study and research are closely connected with management and with regulatory instruments aimed at guaranteeing its correct use and an adequate level of conservation, to guarantee future generations.

The Italian forestry world has understood the challenge well and is gearing up to respond effectively.

Rome, 19th October 2021

Alessandra Stefani
General Director
Directorate-General for Mountain Economy and Forests
MIPAAF

Acknowledgement

Experts who have contributed to the Report

Beritognolo Isacco CNR IRET, isacco.beritognolo@cnr.it
Camerano Paolo IPLA, camerano@ipla.org
de Dato Giovanbattista CREA FL, giovanbattista.dedato@crea.gov.it
Ducci Fulvio CREA FL, FAO-FGR National Focal Point, fulvio.ducci@crea.gov.it, fulviodcc@gmail.com
Ferlazzo Silvia DIFOR, s.ferlazzo@politicheagricole.it
Librandi Immacolata DIFOR, i.librandi@politicheagricole.it
Marchi Maurizio CNR IBBR, maurizio.marchi@ibbr.cnr.it
Mattioni Claudia CNR IRET, claudia.mattioni@cnr.it
Monteverdi Maria Cristina CREA FL, mcristina.monteverdi@crea.gov.it
Nervo Giuseppe CREA FL, giuseppe.nervo@crea.gov.it
Piloni Sara DIFOR, s.piloni@politicheagricole.it
Piotti Andrea CNR IBBR, andrea.piotti@cnr.it
Pompei Enrico DIFOR, e.pompei@politicheagricole.it
Proietti Roberta. CREA FL, roberta.proietti@crea.gov.it
Raparelli Elisabetta. CREA AA, elisabetta.raparelli@cra.gov.it
Sabatti Maurizio UNITUS DIBAF, sabatti@unitus.it
Santini Alberto CNR PSP, alberto.santini@cnr.it
Scarascia Mugnozza Giuseppe UNITUS DIBAF, gscaras@unitus.it
Stefani Alessandra DIFOR Direttore Generale, a.stefani@politicheagricole.it, Difor.direttore@politicheagricole.it
Vendramin Giovanni Giuseppe CNR IBBR, giovannigiuseppe.vendramin@cnr.it
Villani Fiorella CNR IRET, fiorella.villani@cnr.it

Short Names

CICES, Common International Classification of Ecosystem Services

CNR IBBR, Consiglio Nazionale della Ricerca - Istituto di Bioscienze e Biorisorse [*National Research Council - Institute of Biosciences and Bioresources*]

CNR IRET, Consiglio Nazionale della Ricerca - Istituto di Ricerca sugli Ecosistemi Terrestri [*National Research Council - Research Institute on Terrestrial Ecosystems*]

CREA AA, Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria, Centro di ricerca agricoltura e ambiente [*Council for Agricultural Research and Analysis of the Agricultural Economy, Agriculture and Environment research center*]

CREA FL, Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria, Centro di ricerca foreste e legno [*Council for Agricultural Research and Analysis of the Agricultural Economy, Forestry and Wood Research Center*]

CREA, Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria [*CREA, Council for Agricultural Research and Analysis of the Agricultural Economy*]

DGPNA, Direzione Generale per il Patrimonio Naturalistico [*General Directorate for the Naturalistic Heritage*] (MITE)

DIFOR, Direzione Generale Economia Montana e Foreste [*General Directorate for Mountain Economics and Forests*] (MIPAAF)

EC, European Commission

ENEA, Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile [*National Agency for New Technologies, Energy and Sustainable Economic Development*]

ES, Ecosystem services

EU, European Union

FAO, The Food and Agriculture Organization

FBM, Forest Basic Material

FGR, Forest genetic resource

FOREMATIS, Forest Reproductive Material Information System (EC)

FRM, Forest reproductive material

INFC, Inventario Nazionale delle Foreste e dei serbatoi forestali di Carbonio [*National Inventory of Forests and Forest Carbon Reservoirs*]

IPLA-Spa, Istituto per le Piante da Legno e l'Ambiente [*Institute for wooden trees and the environment*] (*Region of Piemonte*)

ISPRA, Istituto Superiore per la Protezione e la Ricerca Ambientale [*Higher Institute for the environmental protection and research*] (MITE)

IUCN, International Union for Conservation of Nature

IUFRO, International Union of Forest Research Organisations

IUTI, Inventario dei paesaggi italiani [*Inventory of Italian Land Uses*]

LNBS, Libro nazionale dei boschi da seme [*National Seed Stands Book*]

MAI - Main Annual Increment

MIBACT, Ministero per i beni e le attività culturali e per il turismo [*the Ministry for Cultural Heritage and Activities and for Tourism*]

MIPAAF, Ministero delle politiche agricole, alimentari e forestali [*the Ministry of agricultural, food and forestry policies*]

MITE, Ministero della transizione ecologica [*Ministry of Ecological Transition*]

MIUR, Ministero dell'Università e della Ricerca [*the Ministry of the university and of research*].

NWFP, Non-Wood Forest Products

ONP, Osservatorio Nazionale per il Pioppo [*the National Poplar Observatory*]

PQSF, Programma Quadro di Sviluppo Forestale [*Framework Programme for the Forest Sector*]

RaF, RaF Italia 2017-2018. Rapporto sullo stato delle Foreste e del settore forestale in Italia [*RaF Italy 2017-2018. Report on the state of forests and the forest sector in Italy]*

RDPs, Regional Development Programs

TUFF, Test o unico in materia di foreste e filiere forestali, Legislative Decree 3 April 2018, n. 34 [*Consolidated law on forests and forestry chains*]

UNITUS DIBAF, Università degli Studi della Tuscia - Dipartimento per la innovazione nei sistemi biologici, agroalimentari e forestali, Viterbo

Second Report on the State of the World's Forest Genetic Resources

National Report: Italy

Executive summary

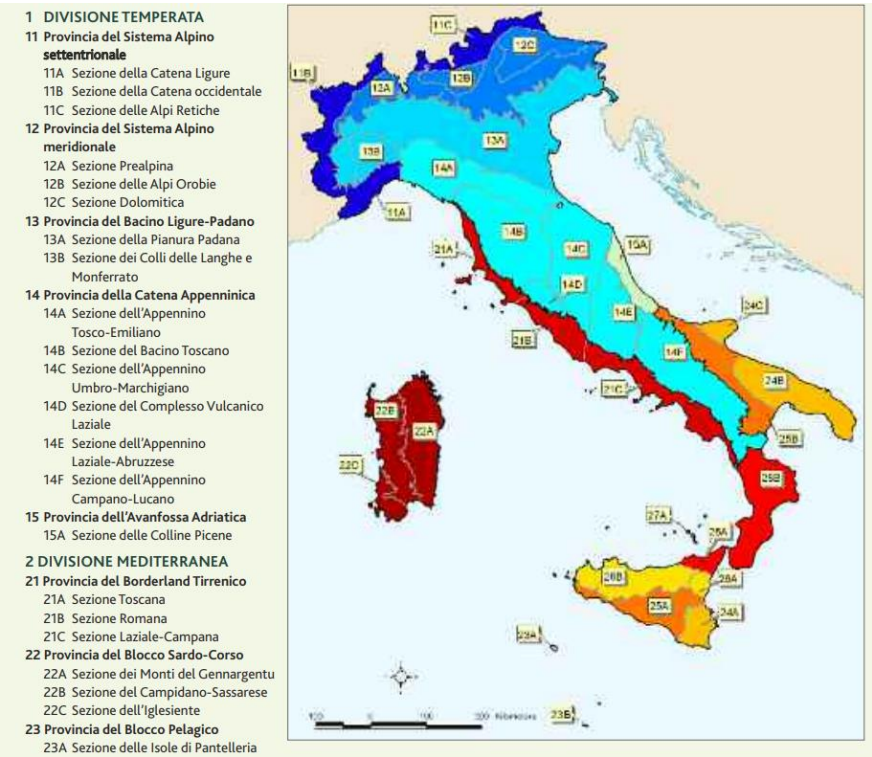
Ducci F. – CREA FL, FGR National Focal Point

The Environment

The territory of the Italian Republic covers 301,225 sq km. Italy lies between the northern latitudes of 47°05'29" (m 2837 from the Testa Gemella Occidentale/Westl. Zwillingskpfe in the Aurine Alps on the Austrian border) and 35°39'26" (Punta Pesce Spada on the island of Lampedusa to the south of Sicilia), and the eastern longitudes from Greenwich of 63°7'32" (m 3178 from the minor peak north of the Rocca Bernauda in the northern Cottian Alps, upper Val di Susa, on the French border) and 18°31'13" (Capo d'Otranto on the Salentina Peninsula).
The structure of the Italian territory differs considerably. Besides the continental section (the Alps and Po-Venetian Plain), there is a long and indented peninsula that is almost completely occupied by the Apennine chain, the two large islands (Sicilia and Sardegna) marking the borders of the Tyrrhenian Sea and many other minor islands (the Tuscan Archipelago, Lipari Islands, etc.). This produces long distances between the country's extremities. In fact, along the Trieste parallel, the extension is about 540 km, while along the Otranto parallel to the western coast of Sardegna, it is about 845 km. Finally, the greatest latitudinal distance is measured along the meridian of the Pelagian Islands, about 1290 km.
It should also be noted that the geographical form of Italy favours the maritime influence on climate with relatively good amount of annual precipitation. Indeed, the innermost parts of the peninsula are just 100 km from the sea (the peninsula's widest point between Mt. Argentario and Mt. Conero does not exceed 240 km), and in the two largest islands, the distance is rarely greater than 50 km. Even for continental Italy, the zone furthest from the sea (the Spluga Pass in the Lombard Alps) is only 230 km away. Finally, about 7500 km of coasts should be added to the land borders, over half of which belonging to the islands. Sicilia has a perimeter of 1115 km, Sardegna 1336 km and the minor islands 1734 km.
The Italian peninsula has been divided into ecoregions (MITE, 2010) consisting of several distinct divisions and subdivisions (Fig. 1), characterised by the great variety of the national territory. Two great Divisions, the Temperate and the Mediterranean one, are the higher level, each subdivided into 5 and 8 Provinces, respectively. Provinces are in addition subdivided into more local Sections.
Different types of forests and forest associations are therefore distributed in the different ecoregions:

- *Tyrrhenian-Adriatic sclerophyllous and mixed forests*
- *Southern Apennines mixed montane forests*
- *Apennines temperate deciduous montane forests*
- *Italian sclerophyllous and semi-deciduous forests*
- *Alpine conifer and mixed forests*
- *Illyrian deciduous forests*
- *Dinaric Mountains mixed forests*

Figure 1. Ecoregion map of Italy (Source: MITE, 2010)



Extensively colonized by relatively poor agriculture until the Second World War, much of the hilly and mountainous territory today sees the results of reforestation campaigns carried out in the past several decades and of urbanization of a large part of rural populations. The most recent forest inventories showed a progressive reconquest of the territory by the forest with consequent changes in the landscape (Sallustio et al., 2013). The forest area has practically doubled since then.

Introduction to Italy's forestry sector

Genetic resources

The number of tree species in Italy is large compared to those growing in central Europe (Falinski and Mortier, 1996), i.e, with the genus *Quercus* alone representing more than 20 species in the region. Among these, up to 15 oak species can be found in Italy. At the same time, at least 6 species of genus *Acer* are represented in Italy, as well as ash (*Fraxinus* sp) with 3 species, *Pinus* (7 species) and several other genera.
Besides the Mediterranean and the Illyric (i.e, originated from the Balkans) forest species contingents, the Italian slopes of the Alpine region are covered by pure or mixed forests of broad-leaved trees dominated by beech, chestnut, oaks and other hardwoods and by conifers dominated by spruce, silver fir, larch, stone pine, Scots pine according to the local conditions.
In Apennines are spread hardwood forests dominated by beech, chestnut, oaks and other hardwoods and conifers, mainly silver fir, and Austrian pine varieties.
In addition, many of the Holarctic and Eurasian tree species survived during the glacial ages in Mediterranean refugia, particularly in the Italian peninsula, from where they re-colonized the continent when temperatures rose again at the end of glaciations, about 15000 to 10000 years ago (Huntley and Birks, 1983; Stewart et al., 2010). In fact, intra-specific genetic variation in species such as *Fagus sylvatica* and *Abies alba* in Mediterranean forests is larger than in other

European forests (Leonardi and Menozzi, 1995). These large reservoirs of genetic variation deserve much more scientific consideration and conservation management measures, also in view of the need for better adaptation of European forests to changing environmental conditions.

Conclusion

Regarding this, it is significant to underline that in addition to the large quantity of genera and endemic species, Italy represents the southern margins of many northern and central European species range, which found refuge here during the glacial periods to contribute to the subsequent re-expansion. Today, many of these marginal or peripheral populations are included in the official Lists of basic forest materials, but they are at high risk of genetic erosion due to intense anthropisation and the shift of climatic belts. Rescue and adaptive management measures must be rapidly undertaken.
Genetics supplied and will offer an outstanding contribution to study variation and the adaptative capacity of this huge amount of forest species as well as progress studying adaptive traits.
The path undertaken under the impulse of the European Directive 1999/105 / EC on FRM and the legislative decree 386/2003 which implemented it, has led to the creation of a vast network of forest basic materials (FBM), especially seed stands, which can provide significant support to all future activities to adapt and save diversity in the country and Europe.

Second Report on the State of the World's Forest Genetic Resources[1]

National Report:
Italy

Chapter 1. Value and importance of forest genetic resources[2]

1.1 The role of the forest sector in the national economy

According to the most recent Italian National Forest Inventory (INFC - https://www.inventarioforestale.org/en), forests cover in Italy an area of about 11 million ha, corresponding to 36.5% of the national land surface (RaF, 2019). Forests and other wooded lands provide a substantial contribution to ecosystem services, such as: climate and carbon mitigation, biodiversity and environmental protection and regulation (Millennium Ecosystem Assessment, 2005). The Mediterranean area is especially sensitive to climate change. Forest trees represent an important component of the Mediterranean flora and Italy is an important biodiversity hot spot with 5463 species, 712 of which are endemic (Falinsky and Mortier, 1992). Hence, the issues related to sustainable forest management are relevant for the economy and societal wellbeing. The Italian Forest area is increasing at an annual rate of 0.5-1.0% as in other European countries and about 2 million ha of new forests have grown up in the last 50 years. They vary in quality, stock, and species composition according to the environmental

[1] NOTE: All Tables cited in the text are at Annex 1 – Tables at the end of this National Report.
[2] This chapter was compiled by Ducci F. CREA FL, Nervo G. CREA FL, Pompei E. DIFOR, Scarascia Mugnozza G. UNITUS DIBAF, Sabatti M. UNITUS DIBAF, Beritognolo I. CNR IRET, Stefani A. DIFOR, Vendramin G.G. CNR IBBR.

conditions. Stand age is relatively young and the mean growing stock is modest with an average value of about 145 m^3 ha^{-1} and a total volume of 1 269 million m^3 (RaF, 2019). Sparse canopies are also frequently present as a category due to the recent forest expansion. However, in Italy the growing stock has steadily increased in the last 50 years, by approximately 50%, thanks to:

- The conservative management of Italian forests that has reduced the rate of utilization to less than 25% of the mean annual increment.

- The silvicultural management that has steadily increased the rotation converting coppice forests into high stands, particularly for beech and oak forests.

- The effects of climate change with the increase of atmospheric CO_2 concentration and nitrogen depositions.

During the last century, an extensive afforestation activity has been conducted all over Italy with the primary objective of soil protection and runoff control. While largely successful, afforestation has produced simplified, pioneer forest ecosystems which will evolve to more complex forests, with increased ecological stability and reduced vulnerability to disturbances, such as fires and pests' outbreaks. Intensive forest tree farming using poplar, valuable broadleaves (walnut, wild cherry, ash, oak) and Douglas fir cover an area of about 100 000 ha in Italy (RaF, 2019). Poplar cultivation, mostly concentrated in the Po valley and traditionally important for wood and pulp economy, declined from 150 000 ha to about 46 000 ha in the last 50 years (RaF, 2019). The total volume of wood and timber logged each year in Italy is estimated around 8 million m^3, with fuelwood produced by coppice forests representing more than 60%. Due to the communal ownership of many forests, statistical data underestimate the real production of wood harvested for local needs. Forest fires are a crucial issue for the Italian forestry, and consequently for FGRs conservation. Abandonment and neglected management of forest land creates serious fire risks, especially during dry winters in the Alpine region and in summer in the Mediterranean area. In the last 20 years about 1% of the forest area has been destroyed by fire each year, with values up to 3% in southern Italy (RaF, 2019). Anyway, a better understanding of the anthropic causes underlying these recurrent disturbances is needed and effective prevention initiatives should be implemented and continuously updated to adapt to social and climate changes.

1.2 Main roles of forests in Italy (supply of wood and non-wood products, provisioning of ecosystem services, etc.)

The Italian forests are managed as coppice (42%), high forest (34%), and other systems not defined (24%). The supply of wood products is related to this partitioning, with fuel wood mainly produced by coppice forests. Imports of wood and non-wood products in Italy account, on average, double of the annual wood volume production (RaF, 2019). The economic value of the standing timber is estimated at about 1 billion € in Italy (RaF, 2019). It is a part of the Italian natural capital, but the major value of Italian forest is related to provisioning of ecosystems services (ES). Sustainable forest management and measures of biodiversity conservation are promoted in Italy to support the provision of forest products and ES. Recently, several LIFE projects have been targeted to the application of sustainable silviculture, certification of fair forest management, development of networks and value chain of non-wood forest products, conservation of forest genetic resources and biodiversity, and improvement of cultural services of forest. Certified forests are about 9% of the total forest area in Italy. According to FAO (2010), "protecting woods and forests" means protecting the most important source of ES. Protected areas in Italy cover 6.8 million ha and represent over 20% of the

national territory. More than half (56.1 %) of Italian forests is within protected areas. Forests provide further regulating ES, such as soil protection, water quality improvement, carbon sequestration, mitigation of pollution and climate change. Forest cover contributes to mitigating the hydrogeological risk from landslides, floods, or avalanches. This issue is particularly sensible in Italy, due to the frequent disasters caused by extreme precipitation events. Carbon stock stored in Italian forests is estimated at 1.24 billion tons of carbon and carbon sequestration by forests is 42.6 million tons of CO_2 per year. Forests supply a multiplicity of ES that have positive impacts on human well-being (Bastian, 2013) and recently their therapeutic value is being studied at national level (Meneguzzo and Zabini, 2020). The economic value of ES is being more and more recognized, but a price system and a market are missing. Recent initiatives aim to establish conventional measures, such as incentives and tax reduction, and new measures, such a system of payment for ES (PES), to economically support the offer of ES by forests (CICES - Common International Classification of Ecosystem Services - https://cices.eu).

1.3 Specific economic, environmental, social, and cultural values of forest genetic resources in Italy

Appropriate FGR are necessary to produce FRM for activities of reforestation and afforestation, with economic and environmental value, and to select plant material for commercial plantations. In Italy, the FGR of some species have a specific economic interest and are genetically improved by breeding programmes: *Cupressus* spp., *Prunus avium*, *Castanea sativa*, *Ulmus* spp., *Populus* spp., and *Eucalyptus* spp. The Italian Ministry of Agriculture, Food, and Forestry Policies (MIPAAF) has recently established the National List of Forest Basic Material (RNMB). The national Technical Committee and the National Poplar Observatory manage the registration of selected, qualified, and tested categories and forest clones for their deployment.
Only a small number of the seed forests included in the RNMB has been characterized from the genetical point of view and has been included in the EUFGIS database (http://www.eufgis.org/) as gene conservation unit. The value of FGR is acknowledged by the public opinion and most of the genetic resources are protected *in situ* at national and regional level. Moreover, 27 forest species are included in *ex situ* conservation programs, of which 12 are conifers and 15 broad-leaved species.
Currently, ES are not specifically attributed to FGR in Italy, as they are generally included in the National Strategy for biodiversity. Anyway, some FGR are part of the cultural heritage and as are many monumental forests and trees. Some examples are the silver fir forests of Camaldoli, La Verna and Vallombrosa in Toscana or Serra S. Bruno in Calabria, the cypress near Fontegreca in Campania, the mixed Mediterranean hardwoods at Ficuzza in Sicilia. The list of monumental trees of Italy, published and updated by MIPAAF, includes some thousands of monumental trees georeferenced and deeply described by the regional authorities.

1.4 Contributions of forest genetic resources to sustainable development in Italy

Biodiversity conservation and forest ES are treated at articles 2 and 3 of the Legislative Decree n. 34/2018 (TUFF, 2018) and FGR are considered in the same text at art. 13. FGR functions are recognized by both the National Forest Strategy and the National Strategy for Biodiversity. Over 12 million hectares of forest can play a key role in mitigating climate change, but they must survive and adapt to a changing environment. Conserving and using genetic diversity is crucial to realise sustainable plantations able to cope with the future challenges (Konnert et al., 2015), as nowadays requested by the Green Deal. Tree populations of the Alpine and Apennine

range are hot spots of genetic and adaptive diversity. Preserving Italian FGR is very important to face global changes acceleration because Italy spans marginal/peripheral populations (rear edges) of mesic tree species with valuable traits for adaptation to difficult environments. The conservation of forest genetic resources is therefore vital for sustainable economic growth and environment protection (FAO, 2014). About 56% of Italian forests are included in national parks and protected areas. Such protected areas are facing many challenges, including increased forest disturbances. Adequate silvicultural management in these areas should be assisted by forest genetic monitoring and specific guidelines (LIFEGENMON, 2020, http://www.lifegenmon.si/). The use of FRM in activities of reforestation and afforestation, regulated by the EU Directive 1999/105/EC (Italian regulation D. Lgs. 386/2003) in Italy falls under the responsibility of the regional administrations. A deep knowledge of FGR through genetic studies *in situ* and *ex situ* are necessary to select appropriate and adaptable FRM. There is a strong need to involve and coordinate the Italian scientific community together with the different stakeholders (FRM supply chain and forest nursery) involved in the FGR management and use.

1.4 Priorities and needs of Italy to enhance these contributions

The major priorities for the maintenance of Italian FGR and to mitigate the impact of climate change on Italian forests are related to: (1) the Mediterranean region will be significantly drier and warmer in coming decades. Associated with climate change acceleration, several disturbances are endangering Italian FGR, such as increased frequency of forest fires, invasive pests, and diseases. (2) The risk of using inappropriate FGR to produce FRM not adapted to the future environment. (3) The diffused low level of management and the abandonment of rural areas and forests represents a real danger for FGR integrity. (4) The Italian forestry sector suffers from a heterogeneous level of governance at regional level. There is the need for a deep genetic and ecological characterization of FGR, as a basis for any strategy. More knowledge on the status and trends of genetic variation in Italian forest ecosystems should consider the organization of research networks to support a long-term vision of FGR dynamics. To establish resilient forests, FRM adapted to changing environments should be selected based on the existing ecological and genetic knowledge. Research and governance institutions should act in a more coordinated manner than in the past. It is necessary to raise awareness of decision makers to make policies on ecological transition that consider the strategic role of FGR. The Italian forestry sector needs a general revision to achieve a homogeneous application of science-based recommendations to sustain FGR and face the challenge of a changing environment and societal needs.

1.5 Perception of different stakeholders on the importance of forest genetic resources

Surveys on European forest stakeholders have been carried out to understand the perception of FGR in relation to their ability to improve the resilience of forest ecosystems and cope with climate change. Fires and drought are perceived as the main threats by Italian stakeholders. There is a general awareness of the potential offered by FGR and attention to the origin and quality in the choice of FRM. There is strong attention to the use of FRM of indigenous origin for native species, but it is not well understood that better adaptable and more productive provenance could also exist. The perception of stakeholders has positive implications for the protection and conservation of FGR. Forest stakeholders need to be more aware about research evidence of benefits from intraspecific genetic diversity and adaptability of plant material (Vinceti at al., 2020).

1.6 The constraints in Italy to increase awareness on the value and importance of forest genetic resources

A major limitation to the recognition of FGR value is the poor social and economic impact of the forest sector in Italy. Dissemination made by the scientific community doesn't reach as efficiently as necessary the level of the policy makers and public audience. The Italian scientific community involved in research on FGR is small. The *ex-situ* germplasm collections and field trials could be used for research, use, dissemination, and training, but they do not receive the due attention and adequate funding. Most Regions have reduced their interest to develop the forestry sector initiatives and the dissemination activity is discontinuous and associated with short-term programmes. The new General Directorate for the mountain economy and forests of MIPAAF should coordinate the players and stakeholder interested in FGR, to define a national strategy and plan to increase social awareness.

Chapter 2. State of forests[3]

2.1 The state of Italian forests

Due to the broad latitudinal extension and the high mountain ranges, Italy hosts a wide variety of vegetation types. These forests support climate and carbon mitigation, biogeochemical cycles, and the rich biological diversity contributes to the variety of the Italian landscape, so many ecosystem services are supplied.
Therefore, the attractiveness of the environment and the productive potential in some pedo-climatic conditions are strengths that should be valued and protected, and forest tree diversity represents an important component of the Italian and Mediterranean flora. The number of tree species is quite large compared to those growing in Europe (100 vs. 30 respectively), i.e, the genus *Quercus* alone representing more than 20 species in the region counts 15 oak species in Italy, as well as ashes are 6 - 7 species compared to 2 - 3 of central-northern Europe. Besides the Mediterranean and the Illyric (originated from the Balkans) forest species contingents, the Italian slopes of the Alpine region are covered by pure or mixed forests of broad-leaved trees dominated by beech, chestnut, oaks and other hardwoods and by conifers dominated by spruce, silver fir, larch, stone pine, Scots pine according to the local conditions.
In Apennines are spread hardwood forests dominated by beech, chestnut, oaks and other hardwoods and conifers, mainly silver fir, and Austrian pine varieties.
. Many Holarctic and Eurasian tree species survived during the glacial ages in Mediterranean refugia, particularly in the Italian peninsula, from where they re-colonized the continent when temperatures rose again at the end of glaciations, between 20,000 and 10,000 years ago (Huntley and Birks, 1989). Intra-specific genetic variation in many trees growing in the Peninsula is higher in Mediterranean forests than in other European forests, as i.e, *Fagus sylvatica* and *Abies alba* (Leonardi and Menozzi, 1995). These large reservoirs of genetic variation, with marginality characteristics (Fady et al., 2016), deserve much more scientific consideration and conservation measures, also in the view of adaptation strategies of European forests to changing environmental conditions.
The Mediterranean Area, being a transition zone between arid and humid regions of the world, can be especially sensitive to climate change and, in this respect, can be an interesting model system to study the effects of global changes on terrestrial ecosystems (Ducci et al., 2015).

[3] This chapter was compiled by: Pompei E. DIFOR, Librandi I. DIFOR, Ferlazzo S. DIFOR and Piloni S. DIFOR.

Forest stand conditions in Italy span from late successional, highly diverse forest ecosystems to stands with reduced biodiversity, either made of planted pioneer species or natural but overexploited coppice stands. Hence, the issues related to sustainable forest management are potentially very relevant.

According to the most recent Global Forest Resources Assessment (FAO – FRA, 2020), forests in Italy about 11.5 million ha, 32.5% of the national land area. This area is divided into "Forest" and "Other wooded land" (OWL) categories, according to a ratio of 83.7% and 16.3%, respectively (Table 2.1).
Analyzing the carbon stock distribution in national forests, Table 2.2 analytically shows the quantitative increase occurred in the period 1990-2020 in the various "carbon pools" of national forests (FAO - FRA, 2020).

Data after the most recent 2015 National Forest Inventory have not been published yet. However, according to the currently available results (Gasparini and Tabacchi, 2005), the national forest area is equal to 10 467 ,533 ha, corresponding to 34.7% of the national territory surface.
The inventory category "*Forest*" represents 83.7% of the total forest area, with 8 759 200 ha, and covers 29.1% of the entire national territory, while the other wooded lands cover 16.3%. The territorial districts with the highest percentage of forest area are Alto Adige, Trentino, Friuli Venezia Giulia, Liguria, Toscana, Umbria, Abruzzo, Calabria, and Sardegna. Among these, the most densely wooded regions are Liguria and Trentino, with a percentage coverage ratio of 62.6 and 60.5%, respectively, while the least wooded regions are Puglia (7.5%) and Sicilia (10.0%).
The other wooded lands, whose extension is 1 708 333 ha (16.3% of the Country surface), are made up of 58.0% of bush, dominated by Macchia and other Mediterranean shrubs.
The most widespread forest categories at national level are formed by temperate climate oaks (*Quercus pubescens, Q, cerris*, *Q. petraea* and *Q. robur*), beech (*Fagus sylvatica*), evergreen Mediterranean oaks, as *Q. ilex, Q. coccifera* and others. Less abundant in Central-southern Italy are *Q. frainetto*, *Q. trojana* and *Q. ithaburensis* subsp. *macrolepis*. *Q. suber*, a species of significant socio-economic meaning, is widely diffused in Sardegna, Toscana, and Lazio.
Concerning silviculture, coppices make up 41.8% of the Italian forest area (3 663 143 ha), with an evident prevalence of coppices with standards (28.0%). In contrast, high forests cover 3 157 965 ha, (36.1%), with a slight prevalence of un-even-aged high forests. The adult and aged stages represent 89.0% of the entire surface, especially coppices, while mature and over-rotation stages are 35.1% of the total. Regarding the vertical structure, 53.6% of woods are characterized by a monoplane structure, while 37.4% by a biplane or uneven / irregular structure.
Conifers cover 852 202 ha, about 8.14% of the forest area, of which 226 101 ha are Mediterranean pines and the others are spread on the Alps or Apennine range.

2.3. The drivers of change in the forest sector in Italy, and their consequences for forest genetic resources

Forests play a key role in the climate dynamics in the Mediterranean context, and Italy is home to a wide variety of forest ecosystems for about 11.5 million hectares.
However, the Italian forestry system is characterized by:
• Lack of integration between forestry and the most advanced wood industry among in the world.
• High import dependence.

• Strong fragmentation of forest ownership, with a significant proportion of agro-forestry holdings of very small size.
Thus, it is clear there is a need of:
• Maintenance of forest ecosystems of conservation value and improving their genetic diversity and biodiversity.
• Strengthening of structural and functional complexity of forest systems.
• Protection of forests, with reference to the need to enhance carbon sequestration and maintain carbon stocks.
• Economic and social enhancement of forest resources and protection of workers and communities.
• Targeted expansion and operation of the specialized forest tree plantations for wood and non-wood production and soil protection.
• To preserve the cultural and historical heritage and landscape of forest land.

The sector “Manufacture of products from wood, cork, straw and plaiting materials” involves in Italy 103 543 employees (RaF, 2019), and it is based on a truly renewable and sustainable raw material. The forests represent not only a secure raw material supply for woodworking and paper industries, but also provide a valuable resource in terms of environmental stability, recreation, tourism, and other intangible benefits.
However, an overview of the Italian forestry system highlights several critical aspects, particularly the modest level of integration between forest activities and the wood industry. In fact, before the pandemic, the annual Italy need was over 40 million cubic meters of forest products but meted a great part of this demand through imports from abroad. This heavy dependence on imports should spur Italy to increase its national levels of production as well as employment in timber plantations.
The reasons that restrict the normal management practices of national forests and inhibit entrepreneurial initiatives are due to several reasons: soil protection needs, due to high proportion of mountain forests with steep terrain, restricted plain areas to be used for agriculture and urbanism, an inadequate network of forest roads, high cost of labor, fragmentation of forest ownership, the complexity of forest laws and regulations at national and regional levels, poor organization of the supply chain, inadequate remuneration of the product by the markets. Nevertheless, the Italian production chain linked to wood is an important economic asset for the country and provides reasonable opportunities for growth and development.
Even though more than a third of the national territory is covered by forests and that Italy has witnessed an increase of the surface and the growing stock in the last century, forest biomass mobilization through forest management and utilization of productive investments has not increased. In the last decades, the national harvesting intensity has been much lower (less than 25% of the MAI - Main Annual Increment) than the European average value (about 65% of the MAI). In addition, the harvesting intensity remains uneven, sporadic and, in some cases, far from industrial processing centers.
The lack of quantitative and qualitative homogeneity also derives from the low professional level in silviculture of owners, which reflects the lower quality of raw products, especially in central-southern Italy. In addition, the internal market of harvested timber makes it even more difficult to meet the market, which has changed dramatically over the last 50 years, moving towards a steady demand for high-quality assortments. Significant opportunities for growth and socio-economic development of mountainous and rural areas can arise by the recognized "multifunctional" role of forest ecosystems for supplying a wide range of environmental services and intangible benefits.

The improvement of the quality and the efficiency of the Italian forest sector, including the provision of ecosystem services and the production of wood and energy, is crucial in the Italian forest national strategy. The strategy has been elaborated within the Framework Programme for the Forest Sector (PQSF) and is consistent with the national and EU commitments: climate change mitigation, biodiversity protection, legislation on the marketing of wood (EC Reg. no. 2173/2005 on Forest Law Enforcement, Governance and Trade) and the import of timber (EC Reg. no. 995/2010 on Timber Regulation). A "National Technical Table" to coordinate all the main actors of the wood value chain has been recently established in Italy, with the following general policy priorities:

- Encouraging the active and adaptive management of the national forest ecosystems, enhancing their economic, environmental, and social value, in accordance with the principles of "sustainable forest management" (as defined by MPCFE-Forest Europe) and the need for adaptation to climate change.
- Enhancing the multifunctionality of forests as "producers" of goods and services.
- increasing mobilization and quality of national forest resources and the related industrial wood products.
- Improving the efficiency and reducing the cost of utilization of national forest resources.
- harmonizing and simplifying the forest legislation while coordinating the various components of the forest-wood-energy value chain.
- Creating local employment.
- Improving and coordinating the forest information and data system.

Finally, it should be actively recognized that the advancement of scientific knowledge and innovation are essential steps to ensure the sustainable management of Italian forest ecosystems while maximizing the potential role of their unique goods and services in building a knowledge-based bioeconomy in the country and the whole Mediterranean region.

2.4. Challenges and opportunities created by trends and drivers for the conservation, use and development of forest genetic resources

Many studies predict that forest vegetation will change because of climate change and an increase in the incidence of related disturbances. However, there is still a great deal of uncertainty about the timing, mode of change, vulnerability of the various species or communities, and the specific future composition of forests. The dynamics of ecosystems with respect to climate-driven changes depends on the ability of the system to develop new structures or processes (emergence), on the interaction between the various components (adaptation) and on the tolerance of disturbances (resilience): three fundamental aspects (Heinimann, 2009) for which it appears essential to observe the behavior of species and forest types over sufficiently large areas (species range). Predictions and models are useful tools to be used alongside the observation of changes that occur in forests. In this context, it is also important to consider the variability of species in their range and the occurrence in Italy of possibly valuable marginal and peripheral populations (Ducci, 2015), and therefore, the response of ecotypes and provenances to both gradual changes in climate, observed along a gradient of altitude or latitude, and abrupt ones, such as extreme events or disturbances (Pignatti, 2011).

Considering the reported information and the rapid changes at the socio-economic level, a corresponding increase in demand for forest goods and services is evident. Therefore, the production, trade and use of appropriate Forest Reproductive Material (FRM) is of upmost

importance for the future of forests. The genetic characteristics of FRM are crucial to ensure adaptation and ecological and economic sustainability, especially in the view of climate change. In the past, decision-makers have often not taken enough account of genetic aspects, but they can determine a major impact on the survival of future forests. Nowadays, the policy is addressed to pay more attention to the genetic quality and origin of FRM.

Foresters can both rely on the natural capacity of tree species to cope with environmental changes and actively help forests survive to stresses associated with climate change. They can actively influence the genetic composition of forest stands by applying proper relevant silvicultural measures and choosing specific FRM for reforestation (Gömöry *et al.*, 2021).

Chapter 3. State of other wooded lands (OWL)[4]

3.1 State of other wooded lands and trends in their management
3.2 Trends in affecting other wooded lands and their management in Italy

The other wooded lands (OWL), namely sparse woods, shrubs, low woods, and shrubs) extension is reported to be 1 708 333 ha in the National Forest inventory in 2005 (INFC, 2005) and over 1 865 000 ha in the Forest Resources Assessment (FAO - FRA, 2020), about 17.8% of the surface of the entire country. OWLs are made up of about 58.0% of shrubs, which considerably contributes to the forest category of Macchia and Mediterranean bush.
The trend of other wooded lands is in line with the one characterizing the forest area, so that area has steadily increased over the last century, thanks to the spontaneous colonization of marginal areas. Recently, a slowdown in the expansion of the forest is observed, probably due to the decrease in the availability of suitable areas.
The increase in national forest areas has also generated a benefit in terms of an increase in forest biomass and - consequently - an increase in carbon storage, as shown in the table below
As for the forest category, the prevalence of private property (50%) is also observed for OWL, while 27% is public property, and the remaining 23% is not classified. About 49% of OWL area is constrained (mainly due to hydrogeological constraints) (Table 3.1).

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

The increasing area of OWLs in Italy is narrowly connected with the intensive urbanization and the consequent land abandonment.
The rapidly settling tree species are characterized by pioneering behavior in these phases of ecological succession, with the ability to rapidly colonize the surrounding soil with root suckers and the prevalence of zoo-choric or anemophilous dissemination over long distances. This implies a thorough understanding of the structure of these populations when they are considered as FRM's source.
The effects of climate change can affect this progressive enrichment of species and their structure could therefore be affected, on the other hand the selective pressure caused by climatic events could over time allow the identification of more resistant species.

3.4 Challenges and opportunities these trends and drivers create for the conservation, use and development of forest genetic resources

[4] This chapter was compiled by: Librandi I. DIFOR, Pompei E. DIFOR, Ducci F. CREA FL.

The intensive agriculture concentrated in the plains has led to the abandonment of the economically more marginal mountain and hills. In few decades, these areas have seen the successional processes restarted from an OWL status towards forest systems, with the establishment of many forest species with a pioneer temperament. Some of these are of considerable productive value, like wild cherry, rowan, ash, and maple trees and are the subject of study by foresters and wood arborists. They also constitute a considerable reserve of genetic information: forming spontaneously in equilibrium with the characteristics of the territory, they could be interesting both for the adaptation and for their high individual component of the variance, typical of these species, which allows for phenotypic selection and consequent genetic improvement.

Several indicators confirm that the Mediterranean region is being strongly affected by climate change. Over the last decades, temperatures have increased along with the frequency of deep and prolonged drought episodes, while rainfalls reduced by up to 20 % in the Italian peninsula as well as in other regions of the Mediterranean (de Dato et al., 2008).

By 2100, temperatures are expected to increase from 2°C to 4°C on average, while precipitations could decrease from 4% to 30% and might interact with the already typical vulnerability of Mediterranean countries related to the general environmental degradation, which is due to the relatively diffused high human pressure (de Dato et al., 2010).

These direct and indirect effects of the global change may lead to huge human, social and economic losses.

Concerning forest resources, especially the genetic ones, the observed and predicted effects of climate change, specifically the increased extreme events, bring new threats forth and risk exacerbating the existing pressures, the environmental degradation, and the vulnerability of Mediterranean ecosystems, particularly the valuable genetic resources contained within.

Together with climate change effects, several cohorts of natural hazards such as pests, diseases and the increased frequency and intensity of forest fires are endangering Italian resources.

Major, sometimes irreversible, changes are affecting the most vulnerable forest ecosystems where marginal populations of mesic species are growing and have probably developed some valuable adaptive traits (e.g., at the rear edges, Ducci, 2015).

The main challenge is thus connected to the opposition to the climate change acceleration, which makes difficult also any adaptation strategy. Only a scientific approach conveying a more in-depth knowledge would be useful to rethink and prepare a strategy. This means that part of the already existing possibly useful data must be reorganized and inferred under a new vision and updated approaches. This requires time, the tools must be adapted to the new needs, and new climatic and phytoclimatic models must be produced. The generally diffused current low level of silvicultural management of our forests constitutes a real danger for the maintenance of these specific populations, which need to be carefully managed *in situ* with proper and well-focused adaptive cultivation techniques, aimed at preserving their diversity and demographic structure, as well (Ducci, 2015; Ducci et al., 2018).

Strategies for the management of Mediterranean mountain forests should carefully consider the issues to strengthen their natural resilience and to distribute resources equally. In this context, urgent initiatives are strongly required to mitigate the impact of climate change on our Mediterranean forest ecosystems and other wooded lands.

Chapter 4. State of diversity between trees and other woody plant species[5]

In Table 4.1, more than 60 woody plant species, conifers, and broadleaves, considered as important FGRs in Italy, are reported.
In September 2021 the most recent data on the Italian forests were finally published, the national wooded area has increased for the last 10 years respect to 2005 by about 587,000 hectares for a total of 11 million hectares, and forest biomass increases by 18.4%. The carbon dioxide absorbed by Italian forests also increases by 290 million tons. Data were provided by the National Inventory of Forests and Forest Carbon Tanks (2015) created by the Carabinieri with the scientific support of CREA.
About 80% of species are included in *in situ* conservation programs and 60% in *ex situ* conservation programs. Breeding activities are conducted on almost 50% of the woody species, and about 50% of the species are molecularly characterized. Among them, poplars spp., Douglas fir, chestnut, walnut, wild cherry, cypress, elms, and eucalypts are the most subjected to breeding and improvement by CREA and CNR institutes. Poplars are surely the most studied from the breeding point of view and genomics (CREA FL).

Nine forest tree species can be regarded as threatened to various extent in Italy (Table 4.2). Six of them, namely *Abies nebrodensis*, *Betula pendula*, *Betula aetnensis*, *Ulmus glabra*, *Ulmus minor*, and *Zelkova sicula*, can be considered as threatened throughout their distribution range within the country. Particular attention should be paid to the cases of *Abies nebrodensis*, *Betula aetnensis*, and *B. pendula* and *Zelkova sicula*, which are species with both a narrow distribution and an extremely limited population size (Parducci et al., 2001; Garfì et al., 2011; Bagnato et al., 2014; Ducci, 2014; de Dato et al., 2021).

Major threats to their persistence came from forest cover reduction/degradation and land use change, often increasing at a regional scale as in the case of *Abies alba* southern populations, pests, and drought (Brunet et al., 2013; Bertolasi et al., 2015). *Abies alba* is locally highly fragmented also in some areas of the Central and northern Apennines (Piotti et al., 2017). *Pinus leucodermis* (or *Pinus heldreichii* var. *leucodermis*) forms disjunct populations widely separated from the core distribution of the species in the Balkans, and are nowadays highly fragmented (Boscherini et al., 1994; Piotti et al., 2014). Another species worth mentioning is *Quercus trojana*, indicated in the category "least concern" in the red list of IUCN. This species has a restricted range in South Italy.

4.5 Threats affected forest trees are both natural and human-caused.

Exotic species can have in some cases a negative impact on genetic resources as replacement of native stands.
Forest species are currently threatened by increasing temperature and isotherm shift together with disruption and reduction of precipitation due to climate changes (Marchi and Ducci, 2018).
Moreover, invasive pathogens are drivers of tree evolution; pathogens can change the size and genetic structure of tree communities. Populations with limited phenotypic plasticity and low genetic variation are expected to difficulty cope with invasive pathogens. An example in Italy can be considered *Castanea sativa* which in in the last decades was affected by *Dryocosmus*

[5] This chapter was compiled by: Villani F. CNR IRET, Mattioni C. CNR IRET, Santini A. CNR PSP, Piotti A. CNR IBBR, Vendramin G.G. CNR IBBR, de Dato G. CREA FL, Monteverdi M.C., Ducci F. - CREA FL

kuriphilus. In addition, examples of anthropogenic activities can be observed in the most densely anthropized areas, i.e. in the Po Valley where widespread phenomena of deterioration of the plain forests occur with English oak, ash, and hornbeam decline, determined in part by the lowering of the aquifers and in part by pollution.

Chapter 5. State of diversity within trees and other woody plants species[6]

5.1 Actions that have been, or are being taken, for assessing and analysing the genetic diversity of trees and other wooded plant species in Italy

A basic prerequisite for mapping and monitoring the genetic variation of forest trees is knowledge of their distribution. There is information on the geographical distribution in the Mediterranean region including most of the representative tree species present in Italy. The pan-European cooperation organization Euforgen has published distribution maps for several tree species in Europe. In 2016, the European Commission published the first Atlas of forest trees in Europe (2016) with information on tree species distribution, habitat, use and threats.
Genetic variation in natural populations is largely influenced by humans. Several factors have an impact, mainly landscape fragmentation, forest damage, different management activities such as regeneration, coppicing, new orchards plantations.
There are few studies on previous and present amounts of genetic diversity in natural populations and cultivated stands of forest tree species. Furthermore, most of the studies have been carried out with different methods, time, and study scales during the last decades. Therefore, it is difficult to discuss trends in genetic variation. Many biotic and abiotic factors may have influenced, in the last decades, the genetic variation of the Italian forest tree species but no comparison has been made before and after such events happened.
Because of globalization, we are assisting to an exponential increase of the introduction and establishment of non-native pests and pathogens. These alien organisms are causing significant impacts on natural ecosystems, leading to a forced succession of species. Even if they may cause important losses, they rarely threaten to extinction the entire species, but the many small scattered marginal populations that probably conserve rare forms, harbor a wide genetic diversity, and hold rare genes that could be particularly useful to improve the plasticity of the species to a changing climate. There are real risks that repeated tree losses and a reduction in the number of genets that effectively contribute to offspring can lead to long-term genetic depletion. For this reason, the conservation, both *in situ* and *ex situ*, of forest tree populations at the southern edge of their natural range should be considered a priority (Fady et al. 2016; Ducci and Donnelly, 2018; Ducci et al., 2018).
One example can be represented by chestnut populations. This species is widely distributed from the Caucasus to Portugal. In Italy, due to its multipurpose characteristics, since Roman times it is present as natural/naturalized populations, coppice, and grafted orchards. Most of the genetic diversity studies refer to populations present and sampled during the late 90's - early 2000 (Mattioni 2008, 2017). After this period new pests and diseases, like gall wasp (*Dryocosmus kuriphilus*) and nut rot disease, caused by *Gnomoniopsis castaneae*, as well as climate change, have probably influenced the genetic variation of such species, but no new monitoring has been made to compare with the early one. *Ex situ* germplasm collections, for

[6] This chapter was compiled by: Villani F. CNR IRET, Mattioni C. CNR IRET, Santini A. CNR PSP, Piotti A. CNR IBBR, Vendramin G.G. CNR IBBR, de Dato G. CREA FL, Monteverdi M.C. CREA FL, Ducci F. CREA FL.

example, and cryo-conserved clonal banks, available at CNR-IRET can be a precious source to refer to.
In Central and Southern Italy, Wych elm (*U. glabra* L.) is a sporadic species. The natural distribution range is discontinuous, and populations are isolated from one another preventing gene exchange. These scattered populations are of great interest because the Apennine Mountains are thought to have hosted glacial refugia of Wych elm, from where the species re-colonised the entire European continent after the last glaciation. These populations are supposed to be rich in genetic diversity and variability, rare alleles, and, therefore worth to be conserved. The recurrence of Dutch elm disease (DED) epidemics, a lethal disease caused by *Ophiostoma ulmi* s.l., threatens these small, fragmented populations with extinction. Furthermore, the increase in temperatures due to climate change allows the insect vector of the disease (*Scolytus* spp.) to reach higher altitudes and in recent years it has been possible to spot Wych elms killed by the DED even at 1300 m altitude where, until a few years ago, it was deemed safe. Actions of conservation are therefore strongly needed, as well as a genetic characterization of these endangered populations.

5.2 Genetic variation and monitoring

Genetic variation of forest genetic resources is one of the key monitoring levels of biodiversity. It provides information concerning the long-term ability of a forest species to survive and adapt under rapid biotic and abiotic changes. Such genetic variation can be measured at phenotypic, physiological/adaptive traits and at the molecular level (AA.VV., 2016).
Different studies are conducted to evaluate the genetic diversity of forest trees by means of molecular markers such as Microsatellite (SSRs) or single nucleotide polymorphism (SNPS) (Mattioni et al., 2017, Villani et al., 2021).
Recently, the development of new genomic technologies and their decreasing cost have given a new impetus to the study of genetic diversity. Techniques such as RAD sequencing to discover and characterize single nucleotide polymorphism (SNP) DNA markers will give new information for conservation and breeding programs for FGRs.
The genetic variation was monitored for different species as recorded in Table 4.1.

5.3 Examples of research on genetic variation

Geographical patterns of genetic diversity in Italy are highly idiosyncratic. Species-specific patterns depend on several factors. Among them, the Pleistocene history and life history traits of different forest tree species emerge as the most relevant. However, clear and coherent pictures can be drawn only for the few species for which a dense map of genetically characterized populations is available for Italy. For example, two of the most relevant forest trees characterizing Italian mountain ecosystems, *Fagus sylvatica* and *Abies alba*, exhibit different spatial genetic structures due to unmatching post-glacial recolonization routes. *A. alba* had at least three Apennine glacial refugia, and the Alps were likely recolonized from the Northern Apennines (Piotti et al., 2017); differently, Alpine and Apennine *F. sylvatica* populations had completely different post-glacial histories, with the Alps being colonized from a Slovenian refugium and the Apennines from a recolonization route originating in Southern Italy (Leonardi et al., 1995; Magri et al., 2006; Magri, 2008). Different locations of refugia and, therefore, different recolonization routes generated quite different geographical patterns of genetic diversity. In *F. sylvatica*, for example, genetic diversity is highest in Southern Apennines while in *A. alba* has two loci, one in Northern and one in Southern Apennines, two different refugial areas for the species. High genetic diversity in populations from Southern Italy has also been shown by studies on organellar haplotypes in oaks (Fineschi et al., 2002;

Bagnoli et al., 2016), but also in this group of species there are exceptions (e.g. Magri et al., 2007) which preclude depicting general patterns.
A more complex pattern on the genetic variation emerges on tree species with historical cultural and economic interest like *Castanea sativa* and *Juglans regia*. Their distribution and evolution have been strongly influenced by a combination of natural events, like glaciations, and human activities, like migrations, cultivation.
A detailed study on the genetic variation of natural/naturalized populations across the entire distribution range of *Castanea sativa* (Mattioni et al., 201) highlights three main gene pools located in the Black Sea/Caucasus region, in the Mediterranean coast of Turkey, Greece, Romania and Bulgaria, one in the central and western Europe (Italy, Spain, France, Portugal, England). These results are congruent with the existence of glacial refugia and the biogeography history of other forest tree species.
Due to the multifunctionality of chestnut, also a comparative genetic variation was assessed at different domestication levels (natural, coppice, orchard). The results offer a complete picture and distribution of the chestnut genetic resources in Europe and provide insights on the role of human activities (Mattioni et al., 2008).
Recently, the integration of ethnobotanical evidence with genetic and linguistic data (e.g., movement of word-related terms) has clarified the complex human manipulation and dispersal pathways of *Castanea sativa* and *Juglans regia* across Eurasia, defining the role of cultural anthropology on their genetic diversification (Pollegioni et al., 2020).
Fewer regular patterns emerge when studying cultivated species or species that are nowadays highly fragmented or sporadic (e.g., Carabeo et al., 2917; De Dato et al., 2020) or focusing on areas where the habitat of widely distributed species is more fragmented (Leonardi et al., 2012; Leonarduzzi et al., 2016).
Studies were also conducted on broad-leaved trees of environmental and economic interest, both so-called "social" and with "scattered" distribution. Among the former group, *Q. robur* and *Q. petraea* (Petit et al., 2002) which rose northward from the Adriatic and Balkan sectors in the post-glacial colonization. For the latter one, particular attention was given to *Prunus avium* (De Rogatis et al., 2013), *Juglans* spp. (Pollegioni et al., 2006a, b), and *Fraxinus excelsior* and F. *angustifolia* (Belletti et al., 2015), all species characterized by high individual variability and poor genetic differentiation.
Finally, there are species, such as *Picea abies* and *Pinus sylvestris*, where contrasting patterns about the phylogeographical relationships among populations and between Alpine and residual Apennine populations prevent summarizing available evidence on the spatial distribution of genetic diversity (Bucci and Vendramin, 2000; Scotti et al., 2000; Cheddadi et al., 2006; Labra et al., 2006; Scalfi et al., 2009; Belletti et al., 2012).
Italian forest tree populations are sometimes included in European surveys of genetic diversity, but often with a very low representation, which precludes extrapolating patterns at the national or regional levels, as discussed for silver fir by Piotti et al. (2017). Other examples involve *Taxus baccata* (Mayol et al., 2016), Mediterranean pines (Vendramin et al., 2008; Jaramillo-Correa et al., 2020; Olsson et al., 2021), *Cupressus sempervirens* (Bagnoli et al., 2008; 2020), *Pinus nigra* (Scotti-Santaigne et al., 2019). Almost all the above-mentioned studies are based on pre-genomic markers (isozymes, nuclear and organellar microsatellite markers, etc). With few exceptions (e.g. Mosca et al., 2012a, b; 2014) there are almost complete lack of studies focused on assessing patterns of potentially adaptive genetic variation in the Italian peninsula, with dense and well-designed sampling aimed at thoroughly elucidating evolutionary dynamics in such an important multi-refugial area spanning high climate variability. As above, genomic assessments at the European level sometimes involve Italian populations [see, for example, studies on Mediterranean pines (Grivet et al., 2013; Ruiz Daniels et al., 2018, 2019; Jaramillo-Correa et al., 2020); *A. alba* (Brousseau et al., 2016); *P. nigra* (Olsson et al., 2020); *P. sylvestris*

(Donnelly et al., 2017)]. Interestingly, Italian forest genetic resources have been recently involved in the H2020 initiatives GenTree and FORGENIUS, which will be focused on producing large genomic investigations at the whole-distribution scale of >20 widespread forest tree species.

5.4 Needs, challenges, and opportunities

Generally, there is a need for more knowledge on the status and trends of genetic variation in representative categories of forest tree species, as mentioned in 5.2 paragraph.
Three challenges are foreseeable soon:
1) Raise awareness of the available forest genetic resources in Italy. The awareness, regulations, policies, strategies, and scientific advisory services specifically concerning sustainable use of forest genetic resources is in general very limited. It appears that only a limited number of specialists is aware of the peculiarity of the past evolutionary history of Italian forests, of their higher genetic variability with respect to other European populations and of their importance as a source of FRM. A more general appreciation of Italian forest genetic resources is urgently needed if the need to re-evaluate autochthonism is an important character to consider when planting new trees.

2) In the absence of specific scientific knowledge, a more precautionary approach must be taken when planting new trees in non-forested and urban areas. The genetic status of seeds or seedlings used for planting should be assessed, prioritising nearby autochthonous population sources of the same species. With the ever-increasing number of planting projects, this is going to be particularly challenging to regulate and organize.

3) The Mediterranean region will be significantly drier and warmer in the coming decades, potentially seeing 40 per cent less precipitation during the winter rainy season. Climate change is going to have a strong impact on the growth and demography of Italian forest populations. Unfortunately, selective forces will act on the genetic variation of the present population in a highly unpredictable way. Therefore, it is the responsibility of Italian forest managers to do whatever they can to maintain the high level of genetic variability typical of these populations. On the other side, a new body of knowledge must be developed to link genes to adaptive physiological characteristics to better predict and manage the evolutionary effects of future selective pressures. It will be particularly difficult to understand the consequences of climate change on the physiology, demography, growth, and reproduction of Italian forest species, to develop management plans to minimize such impacts and produce reproductive material already adapted to the new climate.
Several future steps can be therefore envisaged:
a) a coordinated national database of the existing germplasm banks of the Italian forest tree species according to representative categories as mentioned in 5.2 paragraph.
b) a coordinated repository of the genetic variation based on morpho-physiological traits and molecular markers.
c) keeping old and forming new experimental field trial network following appropriate criteria, which could allow long term data comparison.
d) analysis of old (from germplasm banks) and newly sampled populations with newly developed methods for DNA as well as quantitative traits variation.

5.5 Priorities for capacity building and research needs

Genetic variation is one of the three levels of biodiversity along with species and ecosystem diversity. Genes are of utmost importance in determining the actual or potential value of a

species from an environmental and economical point of view. For this reason, it is essential to promote to government, universities, and research institutions the need to include this level of biodiversity in the long-term studies as well as the species and ecosystem level. In doing so, it is also extremely important that research and governance institutions will act in much more coordinated manner than in the past, also involving stakeholders who are not only the end users but also the caretakers of the forest genetic resources.
In the past, Italian provenances were rarely tested in European provenance trials and Italian samples were often absent from international genetic surveys. In recent years, this pattern has been rapidly changing, but a greater involvement of more Italian forest research groups in a higher number of international research projects is still desirable.
The Italian peninsula represented an important refuge area during the Quaternary era and is the southern margin of the distribution range of several forest species. The complexity of the interactions between historical evolutionary events and the highly heterogeneous Italian environment (with seas, plains, valleys, high mountain chains with different geographical orientations) will likely impede a real understanding of the role of the different factors affecting the genetic structure of Italian forest populations. Moreover, the ancient history of human impact on forests in Italy and the extensive gene flow, typical of many forest species, add another level of complexity to the already complicated background. A sufficiently detailed description of the major genetic differences of populations over their Italian range is available only for a small number of species. More scientific work is needed to better characterize major spatial genetic structures in many other tree species.
Develop forest tree breeding programs and seed production for many tree species to facilitate the choice of forest reproductive material in a changing climate and work more actively with the issue of resistance to existing and new problematic forest pests in the breeding programs.

Chapter 6. *In situ* conservation of forest genetic resources[7]

6.1 Assessing the state of in situ *conservation of forest genetic resources in Italy*

In situ conservation can have different purposes. *In situ* conservation FGR is implemented with a dynamic approach mainly in the network of seed stands and in the networks of protected areas that are established at sub-regional, regional, and national level. As these are generally state-owned areas, these networks can overlap, and many seed stands can already be included or be the core of a protected area. As illustrated above, these networks are established under state and regional laws.
Long-term forest genetic resource conservation, inventory, research, and management programs become fundamental for sustainable forest management in view of predicted climate change at the global level. In Italy, forest genetic resources (FGRs) national conservation strategies/programs, including *in situ* and/or *ex situ* stands, have been established since the late 1940s' and nowadays is also in the framework of international networks such as FAO Silva Mediterranea, IUFRO Division 2 units, EUFORGEN and European and National Conservation Programs and several research networks.
In situ conservation is carried out through the National and Regional protected areas network, other local natural reserves (i.e., Natura 2000 network) and the network of forest basic materials (i.e., seed stands, Table 4.1).

[7] This chapter was compiled by: Raparelli E. CREA AA, Monteverdi M. C. CREA FL, Librandi I. DIFOR, de Dato G. CREA FL, Santini A. CNR IPB, Proietti R. CREA FL, Ducci F. CREA FL.

In situ conservation programs have been implemented for all native trees and other woody forest species, including threatened tree species (i.e., *Abies nebrodensis* - extinction risk according to IUCN red list). Special attention is being paid to marginal and peripheral populations threatened by environmental and anthropogenic factors.
From July 2021, Italy has completed, through the Ministry of Agricultural, Food and Forestry Policies, its national information system of FGR (MIPAAF - Risorse genetiche forestali politicheagricole.it)). It contains information on the national network of forest basic materials, summarizing the regional subdivisions. With the D.M. n. 9403879 of 12th March 2020, published in the Official Gazette No. 47 of 25th February 2021, the National List of Basic Materials is established, aimed at the enhancement of forest genetic resources, through the definition of the aspects relating to the admission of FBM in the regional lists and the establishment of the National List of FBMs. *In situ* seed stand recorded are at present 2130, of which 170 "selected" and the others "source identified" as a valuable reserve of genetic information.
It is fed by the Regional Lists of Basic Materials of the Regions and Autonomous Provinces of Trento and Bolzano for the about 50 species listed in Annex I of Legislative Decree 10 November 2003, n. 386. This register contains the specific data relating to each basic material together with the unique reference of the record or identity code. The Directorate General for the Mountain Economy and Forests (DIFOR) provides for the keeping, updating and publication on the national and community websites of the National Register. The collected data will be uploaded to the FOREMATIS system, a system made available to the Member States by the European Commission.

6.2 Approaches being used for in situ *conservation of forest genetic resources in Italy*

In 1948, in collaboration with the General Directorate of Forests, the former Experimental Forestry Station (nowadays CREA, Research Centre for Forestry and Wood) established the first National Seed Stands Book (LNBS) to register sources of seed procurement for forestry. This led to the launch of a process for establishing a national inventory of FGRs. Since that time, Italy has developed a national and sub-national operational system of *in situ* conservation for FGRs.

Indeed, with decree 21st May 1948 by the Ministry of Agriculture and Forestry, the Experimental Forestry Station of Florence was appointed to provide all the surveys, inspections, and research necessary to establish and update the LNBS. The registered seed sources were characterized at site, ecological, structural, silvicultural, and productive level; management directives for improving quality and genetic variation were also indicated.

In June 1949, the first survey of seeds sources was completed, and the phenotypic selection work began together with plus trees selection for the most economically valuable species.

On 30th March 1950, the first forest seed stand network was established and formally registered by the Italian Ministry of Agriculture and Forestry into the LNBS. In June 1950, 43 forest seed stands were registered in the LNBS. A ministerial circular prescribed that only FRM deriving from seed stands selected and registered in the LNBS could be used for reforestation and afforestation activities. At the same time, experimental comparative tests were conducted to evaluate the actual genetic value among provenances previously selected only on a phenotypic basis. In the 1960s, the European Community and subsequently the OECD established rules for the control of the genetic value of FRM that led to the issuing of the EEC Directive 404/66 and the 1967 OECD system. Italy transposes this directive into the Law 269/1973,

implementing the FRM Italian control system through the LNBS and the Register of Forest Clones.

Subsequently, with the issue of the European Community Dir. 1999/105/EC, the Law 260/1973 was revised and amended with the Legislative Decree 386/2003. In 2020, the national technical Committee updated the species list and the selection criteria for seed stands and the management of FRM.

Since 2003, the Italian system has assigned the specific competencies for the conservation and management of FGRs *in situ* to the Regions, which can manage them implementing the 386/2003 Legislative Decree. Annually, each Region provides to the FRM National Committee, near DIFOR, the main shared data related to *in situ* conservation (FRM movements, notification, and registration of new seed stands).

In Italy, *in situ* conservation programs are based on the principle of conserving forest genetic resources in a variety of locations under different environmental conditions and management systems, thus ensuring efficient conservation of the species genetic variability. The main objective of the Italian *in situ* conservation strategy of FGR is to maintain high levels of diversity within the genetic conservation units and species across all national territory.

Italy was a glacial refuge for numerous forest species typical of northern ecosystems. With the subsequent rise in temperature, these species began to migrate again along the peninsula until they reoccupied the high latitudes. During this migration, refugial populations remained peripheral and isolated or marginal. These populations, evolving in more extreme climatic conditions, may have selected useful characteristics, representing an important genetic heritage to be evaluated, preserved, and propagated in relation to climate change and future scenarios. From this point of view, Italy can be considered an important biodiversity hot spot. For this reason, one of the main approaches adopted is to conserve marginal genetic resources at risk of erosion due to global changes with ecological criteria and maintenance of evolutionary dynamics.

To improve the resilience of forest stands to climate change in Italy, various *in situ* conservation strategies are being proposed and tested:

- Conservation of forest stands structures through sustainable forestry.
- Dynamic adaptative conservation strategy of forest stands through sustainable management considering the variability of climate and its changes during time, by programming forest management and interventions based on climate cycles.
- Developing methods for the proper management of FGRs: assisted gene flow / migration, re-location, and choice of alternative species for forest stand where the impacts of climate change are anticipated to be more severe.
- Continuous monitoring (e.g. climatic, dendro-structural, genetic and phenological) of experimental areas in forest stands.

6.3 How the in-situ *conservation of forest genetic resources is organized in Italy*

In Italy, *in situ* conservation of FGRs are mainly organized into a set of different kinds of categories, which are also considered as conservation units: seed stands (Table 6.1), biogenic reserves (Table 6.2) and protected areas (Table 6.3).

In situ conservation network include about 51 target forest species for a total of 2130 stands (Tables 4.1 and 6.1) subdivided into seed stands (520,201 ha - Table 6.2), biogenetic reserves and protected areas (119,576 ha - Table 6.3), of which many are marginal populations.

The conservation and responsible and / or sustainable use of forest genetic resources is a fundamental aspect of forest management, and it is integrated with forest management policies and guidelines. Ensuring sustainable use means maintaining or restoring the genetic integrity of populations, guaranteeing evolutionary adaptation towards the future, especially in the light of ongoing climate change.

Conservation of RGF traditionally takes place in two ways:

• *evolutionary or dynamic*, which pursues the conservation of the population (s) in such a way that the species can interbreed and select naturally

• *static*, where the conservation of existing genetic diversity is pursued, keeping the genotypes in collections.

Depending on the location, these two modalities are carried out *in-situ* or *ex-situ* according to the programmes and the species.

The EU Directive 1999/105 / EC, implemented in Italy with Legislative Decree 386/03 does not provide specific indications about forest management as a genetic resource; rather, it indirectly refers to the management tools already in force in forestry and environmental matters.

The Legislative Decree n. 34 of 3 April 2018 - Consolidated law on forests and forestry chains (TUFF) deals with the RGF theme in art. 13 - Forestry propagating materials. In addition to implementing the Legislative Decree 386/03, the TUFF delegates the trade and management of FRM to the individual regions; also, in this case, it does not explicitly refer to the *in-situ* management of RGF, except by referring to management regulations to be integrated with forest and environmental planning at the regional level.

At the local-regional level, the legislative landscape is varied, as can be seen below; six are regulatory measures on forest management and the corresponding regulations or implementation deal with the issue of FGR management. Some considerations can be made on Table 6.4:

• *Transposition of European and national legislation*, most of the Regions have implemented Legislative Decree 386/03 except for Val d'Aosta and Liguria, although in the latter there is a list of seed woods compliant with the Directive; in all regional forest laws, except for Val d'Aosta, the issue of forest nursery is addressed as a fundamental tool for the protection, conservation and use of indigenous forest material of specific origin.

• *Forest genetic resources*: in most of the more recent regional regulatory measures, the issue of biodiversity conservation is generically cited; however, there is no connection with the forest as a genetic resource and that the "seed woods" represent the areas of the greatest importance which, together with forest nurseries, represent the operational tools for the management of FGRs.

• *Seed stand management regulations and specific interventions*: the issue of managing FGRs in relation to traditional forms of governance and treatment is addressed in the laws and regulations of Piemonte, Lombardia, Toscana, Lazio, Marche, Abruzzo, Campania, Molise, and Sardegna and in the implementation of legislative decree 386/2003 at the national level.

In all other cases, the legislator does not deal with defining specific forest management, but indirectly delegates the planning tools in force and the sensitivity of the planner, but always within the context of traditional forms of governance and treatment.

Therefore, it is observed how the regulatory instruments at the various levels pay particular attention to the FRM supply chain in the purely nursery section, neglecting forest management models. This aspect is particularly significant in relation to the abiotic threats and damage due to climate change.

In this context, however, the TUFF, by addressing the issue of ecosystem services provided by the forest, indirectly identifies FGRs as an ecosystem service and sets the general objectives of sustainable forest management.

Specific management interventions
Regarding possible interventions financed through the Regional Development Programs (RDPs), several Regions have activated measures to improve the ecological stability of the forests. As an example, Piemonte with the PSR (Rural Development Plan) 2000-2006 has activated the specific Measure I7 on seed forests and over 80 forest plans involving RGF, of these about 30 contain a specific management specification to manage FGR,

Management regulations - minimum information required.
Silvicultural management for a stand suitable for seed collection must be based on the following assumptions:
1. Length of shifts very close to the natural ones of the species in order to fully exploit the productive period: in the first years of fruiting, as for senescent trees, the quantity produced, and the quality are scarce and irregular.
2. Densities must be very low to guarantee the maximum surface of the canopy with good or excellent lighting; furthermore, to facilitate the collection of the seed, it is necessary that the lower arboreal and shrubby layers be little present. In this regard, it should be noted that the density conditions are not the same for all species but must be defined individually.
The methods and types of management intervention depend on the evolutionary-cultural structure or on the structural type.

6.3 The main players / stakeholders of in situ *conservation*

The main players and stakeholders involved in *in situ* conservation are the Ministry of Agriculture, Food and Forest Policies MIPAAF, Ministry of the Environment, Ministry of Defense - Biogenetic reserves, Regions, local Communities, different research bodies (i.e,, CREA, CNR) and Universities.
Here below (Table 6.5), is the link to the main bodies involved:
Mipaaf - Risorse genetiche forestali - Elenco degli organismi ufficiali (politicheagricole.it)

6.5 Criteria applied for identifying or establishing new in situ *units or areas for the conservation of forest genetic resources*

The conservation of forest genetic resources is regulated by the OECD scheme for forest reproductive materials and by national rules implementing the European directive 1999/105/CE, D.lgs. 386/2003 (http://www.camera.it/parlam/leggi/deleghe/03386dl.htm) and its updated decree 30th December 2020. Description forms were integrated with Euforgen descriptors.

6.6 Needs, challenges, and opportunities for improving in situ *conservation of forest genetic resources*

- A new forestry strategy (governance by TUFF) that contemplates the entire forest nursery chain from the identification and selection of the most suitable basic material in relation to the stationary conditions and future climatic scenarios, with a view to conserving biodiversity and increasing ecosystem resilience and services connected ecosystems, up to the planting of the planting, with traceability of the entire path, for statistical and programmatic purposes (territorial / landscape management planning), for productive, protective, landscape, urban forestry, and recreational / tourist purposes and forestry aims as defined by the EU Directive 199/105/CE and by the Legislative Decree n. 386/2003.
- Creation of a Decision Support System (DSS), which can support stakeholders making strategic decisions in resilient ecosystems planning using FGRS.

6.7 Priorities for capacity-building and research in this area

- Research on conservation programs related to global change effects.
- Research on adaptive potential of tree populations and assisted gene flow.
- FGRs management to support a territorial planning more resilient to climate change.
- Capacity building at regional level.
- Increase the funding programs for *in situ* conservation.

Chapter 7. *Ex-situ* conservation of forest genetic resources[8]

7.1 How the state of ex-situ conservation of forest genetic resources is assessed in Italy

In Italy, 81 forest species are or were subject to *ex-situ* conservation programs, 27 of them are conifers and 54 broad-leaved species (Tables 4.1 and 7.1). About 371 *ex-situ* conservation sites are divided into 140 collections of provenances and progeny tests and conservation stands, 95 clone banks and 136 seed banks, distributed throughout the country. About 2802 accessions + 10827 clones are included in *ex-situ* conservation programs. Hybrids of poplars, elms, walnuts, eucalypts, and cypresses are included. Of the total conserved material, 82% is native and 18% exotic.

About 470 ha are designed and managed for *ex-situ* conservation (Table 7.3). The *ex-situ* conservation program of *Pseudotsuga menziesii* covers about 55% of the entire area with about 259 ha of seed stands, collections, provenance, and progeny tests.

7.2 Approaches being used for ex-situ *conservation of forest genetic resources in Italy*

A national operational *ex-situ* conservation system for FGRs was established since 1922 when the network of exotic species introduction tests was created by the former Royal Station of

[8] This chapter was compiled by: Raparelli E. CREA AA, Monteverdi M.C. CREA FL, Librandi I. DIFOR, Santini A. CNR IBP, de Dato G. CREA FL, Proietti R. CREA FL, Ducci F. CREA FL.

Silviculture of Florence (nowadays CREA Research Centre for Forestry and Wood). The network still exists, and it has been the initial core of all the following *ex-situ* activities for both exotic and native species.
Ex-situ conservation approaches can be both dynamic and static, or combined.
In most cases, the *ex-situ* conservation relates to experimental networks either at the national or international level. Currently, 140 *ex-situ* conservation units are registered, divided among provenance collections, provenance and progeny tests, seed orchard, and 23 clone collections (Table 7.2). In addition, some seed banks exist in Italy (e.g. Centro Nazionale Carabinieri Biodiversità Peri - VR, Centro Nazionale Carabinieri Biodiversità Pieve Santo Stefano - AR). Besides allowing biodiversity conservation, they complement *in-situ* conservation, providing sources of Forest Reproductive Material (FRM).
The most meaningful species for adaptive, productive, landscaping, and economical purposes are addressed towards genetic improvement and breeding activities at provenance, progeny, or clonal level, according to the variation levels required by the planting environmental and socio-economic context. *Castanea sativa* is one of the most forest species and materials from the most representative areas are conserved *ex situ* (Turkey, Greece, Italy, Spain) and about 200 populations with a total of about 4000 samples from the whole distribution range (wild and cultivated varieties) are cryopreserved in a germplasm bank.

Ex-situ conservation activities also exist in for endangered species/population rescue. In the last decades, to preserve some species at risk of extinction and not lose their biodiversity and important gene pools (Tables 7.1 and 7.2), experiments of dynamic *ex-situ* conservation (assisted gene flow and migration) have been launched.
Assisted migration methods are being considered and studied, in relation to the possible new climatic scenarios envisaged for the Mediterranean region, and the widespread patched distribution of marginal and peripheral populations of several native species.
An important example of assisted species/population migration concerns the Sicilian fir (*Abies nebrodensis* (Lojac.) Mattei), highly endangered *in situ*. It covers a small area in the Madonie mountains in Sicilia. It is the southernmost population / species of fir in Italy that due to fires, tourism, genetic erosion, and climate change is at risk of extinction (IUCN red list). Currently, the population is made up of only 29 - 30 adult trees. CREA FL has developed a dynamic *ex-situ* conservation strategy: the entire population was translocated to better contexts to restart new dynamics and preserve the current gene pool. In 1992 - 93, two grafted clonal archives / seed orchards were created in the northern Apennines, 1200 km further north of Sicilia.
Since 2000, the orchards have been started producing pollen and cones. Consequently, a new population of *Abies nebrodensis* is being created according to an open dynamic method. "Half-sib" seedlings are being progressively planted in two experimental sites with pedo-climatic characteristics suitable for the species, considering a buffer zone of more than 1000 meters to avoid risks of genetic pollution from other possible fir trees in the area.
Another significant case study of assisted gene flow and migration in Italy is the Oak Forest of Carpaneta near Mantua (northern Italy). This stand represents an important lesson of assisted gene flow to restore the biodiversity of an endangered forest gene pool. It is an example of a new forest ecosystem (planted in 2003 by CREA in collaboration with the Region of Lombardia) with pedunculate oak and sessile oak (*Quercus robur* and *Q. petraea*) as dominant trees, re-established in an area traditionally completely cleaned by intensive agricultural land use. Seeds were collected from a set of 15 natural populations patched along the whole Po valley. The aim was to establish a genetic reserve of *Q. robur* and restore the interrupted gene flow in a 45 hectares artificial population located in the barycenter of the ancient Po Valley range of the species.

For poplars, a decree has been issued that regulates poplar cultivation for *ex-situ* conservation of clones (Ministry Decree n. 17132/2015. The National Poplar Observatory (ONP) is a standing committee established in 2015 also appointed for evaluation and clone's registration of forest species.

7.3 Organisation of ex-situ *conservation of forest genetic resources in Italy*

Twenty-seven species are preserved *ex-situ* in field collections (conservation stands, provenance and progeny trials, seed banks, clonal collections) and germplasm banks (i.e,, seed bank).
The National Strategy for Biodiversity considers several tools for preserving forest biodiversity, including the establishment of National Forest Biodiversity Centers. At present, two biodiversity seed centers belong to the State and are managed by Carabinieri Forestali. (https://www.mite.gov.it/sites/default/files/archivio/allegati/biodiversita/Strategia_Nazionale_per_la_Biodiversita.pdf).

7.4 Main players / stakeholders of ex-situ *conservation*

The operational system comprises different components, such as *ex-situ* conservation stands, field collections, storage facilities for seed, pollen, or other tissues, belonging to state and regional services, public research institutions, privates. Most of them are managed by national research institutions (i.e., CREA, CNR) in collaboration with MIPAAF-DIFOR, Ministry of Defense – Carabinieri Forestali (previously Corpo Forestale dello Stato, CFS) and some Regions (Table 7.4). Indeed, in addition to the collections, provenances and progenies tests managed by the research centers, seed centers for storage facilities have been established in Italy since the '60s. Currently, they are named Biodiversity Conservation and Distribution centers. They are managed by the Ministry of Defense that inherited the forestry domain, previously managed by the State Forest Service and now in charge of Carabinieri Forestali. Some regions also established small facilities for their own use or special purpose, such as Lombardia, Venice, Friuli-Venezia Giulia, Marche, Molise, Campania, for usual FRM and truffle production, and Sardegna for cork oak.
Among the main players/stakeholders involved in ex-situ conservation programs the poplar grower's consortium of the Po Valley, and trade associations in the nursery-forest seed sector as ASSOSEMENTI can be cited.
Recently, the Centro Regionale Castanicoltura del Piemonte - established in 2003 by the Piemonte regional administration, University of Torino, and local Institutions, and formalized by the Regional Law n° 4 of 10 February 2009 – has been recognized as a Center for the conservation and the pre-multiplication of *Castanea sativa* Mill. for the study and conservation of chestnut germplasm (Decree of 20 November 2020), where genetic, breeding and reproduction activities are developed.
CNR IRET must be also recorded for its germplasm bank hosting 200 wild and fruit crop chestnut cryopreserved varieties.
Noteworthy is also the Italian Network of Germplasm Banks for the *ex-situ* conservation of the Italian spontaneous flora RIBES (http://www.reteribes.it/index.asp), which, has been an associate member of GENMEDA - Network of Mediterranean Plant Conservation Centers (www.genmeda.org) since 12 November 2018.

7.5 The criteria applied for establishing new ex-situ *units or collecting new accessions*

The main criteria applied in Italy for establishing new *ex-situ* units or collecting new accessions derive from the guidelines for the retrieval and use of basic forestry materials Dir. 105/1999 CE (Belletti et al., 2005; AA.VV., 2010) and the EUFORGEN guidelines (Kelleher et al, 2015; Konnert et al., 2015; Rudow et al., 2020). Specifically, these criteria are:

- Estimation of the variability of the species / population, considering not only phenotypic traits but also the genetic variability, estimated using molecular markers.
- An intra-species and population sampling by collecting seeds or other propagules on several mother trees (about 50 mother trees / population), with a minimum spatial and ecological distance of mother trees to capture maximal genetic diversity to optimise the potential for genetic adaptation (from 50 to 100 meters between mother trees).
- Reproduction of sampled genotype ensuring the survival and growth of all reproductive material collected in the original population.
- Adoption of measures to favour the inter-fertilization among the sampled genotypes. To this end, it is necessary to create plantations that tend to reproduce the panmictic equilibrium, identifying sites in the optimum of the species that ensure full flowering and fruiting, in which the possibility of contamination from external genetic flows is absent or minimized. A minimum distance from other populations of at least 500/1000 meters is suggested, an extension of plantation area which allows obtaining a sufficiently wide artificial population to ensure adequate flowering synchronism, sufficient levels of cross-pollination and reduction of any effects of genetic drift and inbreeding.
- Moreover, it is recommended to establish at least two *ex-situ* copies for each valuable conservation unit, and to provide a monitoring system to assess their development and variability under the conditions at the chosen sites.
- When the *ex-situ* dynamic conservation is not possible, the species/populations can be maintained in stasis in a seed bank or gene bank.

7.6 Transfers of tree germplasm within and/or outside of Italy for ex-situ *conservation.*

Transfers of tree germplasm within the European Community are regulated by EU Directive on Forest Reproductive Material 1999/105/CE (Dlgs. 386/2003 - Implementation of Directive 1999/105 / EC on the marketing of FRM, and its updates Decree 30 December 2020 - Establishment of the National Register of Basic Materials [21A01150 – Gazzetta Ufficiale della Repubblica Italiana, Serie Generale No 47 of 25/02/2021), according to the OECD scheme for Control of FRM moving in International Trade / 2019 and Legislative Decree 214/2005 "Implementation of Directive 2002/89 / EC on protective measures against the introduction and spread within the Community of organisms harmful to plants or plant products".
Pursuant to art. 1 of Regulation (EC) n. 1598/2002, if the FRM is transferred from one member state to another, the official Authority of the member state where the supplier is based communicates information to the homologous Authority of the member state of destination. This information is notified by means of an information document drawn up according to the standard model envisaged by EC regulation n. 1598/2002 and reported in Annex 5. The information must be sent within three months following the date of shipment of the FRM by the supplier (according to Article 6 of the decree of 30 December 2020).

The transfer of tree germplasm to third countries follows the Nagoya protocol - Protocol on Access to Genetic Resources and Equitable Sharing of Benefits, decision 283/2014 and Regulation EU 511/2014. Italy joined the Nagoya Protocol on 23 June 2011, at the same time as the European Union and 11 others of its member states, during the signing ceremony organized by the Secretariat for the EU Member States at the United Nations headquarters in New York. The Protocol entered into force on 12 October 2014, coinciding with the COP 12 of the Convention on Biological Diversity (CBD).
The Protocol identifies the different phases of the procedure for accessing genetic resources and sharing the benefits deriving from them (Konnert et al, 2015). Anyone who intends to use a given resource (i.e., a company or a researcher) applies for access to the country providing the resource itself. To this end, each State must set up a national service to centralize applications. The supplier countries, and possibly the local communities, must give their preliminary consent, with knowledge of the facts, for a targeted use of the genetic resource: in this sense, the Protocol speaks of "Prior Informed Consent - PIC". Furthermore, contractual clauses must be established between the two parties defining the method of sharing the benefits with the countries or with the supplier communities ("Mutually agreed terms - MAT"). PIC and MAT are, therefore, the two main clauses that a user must satisfy to access a genetic resource. The authorization, or certificate of compliance, is then issued by the competent national authority of the supplier country: it must prove that access to genetic resources has occurred in accordance with the PIC and that the MATs have been defined.
The correct path of the genetic resources is then verified by special control points called checkpoints.
Information relating to access and benefit sharing is shared through the "Clearing House Mechanism" access and benefit sharing exchange center used to exchange information on licensing and the origin of resources for which the certificate of conformity has been issued. Collected material post-CBD and pre-Nagoya is not subject to EU Regulation 511/2014, but it can be subject to national laws.

7.7 Needs, challenges, and opportunities for improving ex-situ *conservation of forest genetic resources*

New and constant economic resources (funding) and new infrastructures to support and protect collections and field tests. This is important to ensure *ex-situ* conservation programs over time and according to rigorous scientific criteria.

7.8 Priorities for capacity-building and research in this area

- Research on conservation programs related to global change effects.
- Capacity building at regional level.
- Renewing resources with new campaigns.

Chapter 8. The state of use[9]

8.1 How, and for what purposes, forest genetic resources are used in Italy

In Italy, FGR included in Annex I of Legislative Decree n. 386/2003, are employed for different forest aims and purposes, including the direct use of wood for energy production (fuel), but also the industrial processing to obtain pulp, paper and board and wood furniture (paper and wood furniture industries play a very significant role in the Italian economy, since more than a third of the production is exported). FGR are then used for high-quality wood production, reforestation, agroforestry systems and non-wood forest products (food, mycorrhization with truffle, fodder, pharmaceutical industry, etc.). As well as for these purposes which have a direct economic impact and assessment, the FGR provide a valuable resource in terms of ecosystem services, through environmental protection and stability (soil and water conservation including watershed management, soil fertility, gas exchange and climate regulation), genetic diversity conservation, landscape and social or cultural purposes (educational and spiritual values, sense of identity, aesthetic and recreational values, tourism). The main use and purposes of FRM produced from FGR in Italy are reported in Table 8.1.

8.2 National (or sub-national) strategies, guidelines, and recommendations for using forest genetic resources in Italy

At national level, guidelines, and recommendations for using forest genetic resources are provided by the Legislative Decree n. 386/2003 on trading Forest Reproductive Material (FRM), which fixes the forest aims where the 1999/105/CE EU Directive must be applied, and the Legislative decree n. 34 of 03rd April 2018 "Consolidated text on forests and forestry chains" (hereafter called "TUFF"). Purposes pursued by TUFF are consistent with the European guidelines defined by the forestry strategy of the European Union (COM 659 of 20th September 2013), with both the international conventions on biodiversity and international commitments signed by the Italian Government in the matter of climate, environment, landscape, and socio-economic development. One of the fundamental purposes of TUFF is sustainable forest management, to strengthen over time forestry, guaranteeing the multifunctionality, the diversity of forest resources, their protection in terms of extension, geographical distribution, ecological and bio-cultural diversity. The protection of FGR also promotes the fight and adaptation to climate change, the landscape, the prevention, and protection from natural risks of hydrogeological instability and fire, and the socio-economic development of mountain and inland areas (Articles 1, 2 and 3 of TUFF).

Proper management of forest genetic resources also requires the use of certified FRM as intended for forestry purposes, according to the Legislative decree n. 386 of 10th November 2003, which implemented the European directive n. 1999/105/EC. This aspect is dealt with by Article 13 of the TUFF, for which the FRM is that defined by article 2, paragraph 1, letter a), of the Legislative decree n. 386/2003. TUFF, besides updating the regional Lists of basic materials, to protect the biodiversity of the national forest heritage, also identifies the National Centers for the study and conservation of forest biodiversity, formerly seed centers of the State Forest Service, nowadays managed by Carabinieri Forestali, located in Pieve S. Stefano

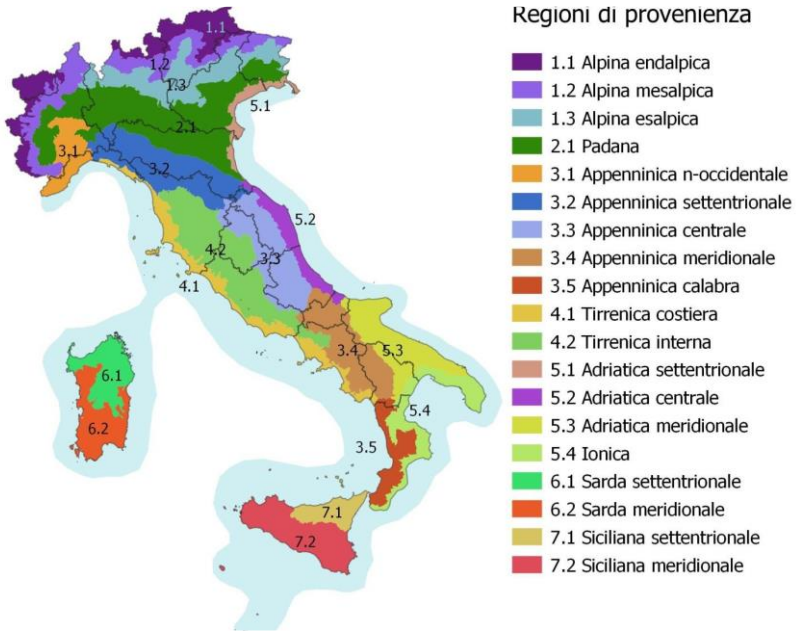
[9] This chapter was compiled by: Raparelli E. CREA AA, Proietti R. CREA FL, Monteverdi M.C. CREA FL, Librandi I., de Dato G. CREA FL, Pignatti G. CREA FL, Camerano P. IPLA, Scarascia Mugnozza G. UNITUS DIBAF, Ducci F. CREA FL.

(Arezzo) and Dogana di Peri (Verona). Three other centers are being approved in 2021. Centers are authorized to officially certify the analyzes on the quality of forest seeds and can assist Regions in identifying the areas of origin and basic materials by collaborating with research centers and European and national institutions operating in the field of FGR from which FRM is sourced.

Beside the above Legislative decree and the European directive, FRM are under the umbrella of the OECD scheme. They are commercialized by different kinds of basic material (seed sources, seed stands, parents, clones, seed orchards) and by different certification categories (sources identified, selected, qualified, tested), distinguished by a different label color (yellow, green, pink, blue respectively). FBMs are uploaded in the Italian National List of Basic Material, where all relevant data and provenance regions, are recorded.

The Provenance Regions are considered the basis of the correct management and use of the FGR in the territory and will be increasingly so in relation to the effects of climate change. Parallel to the National Register of basic forestry materials, a new National map of the Provenance Regions (PR) was drawn up under the coordination of DIFOR which, on a GIS basis, can be adapted to future climate scenarios. Next steps will be addressed towards single species PR integrated on genetic data.

Figure 8.1. D.M. N. 269708 of 11/06/2021 - Subdivision of the Italian territory into Provenance Regions



The Italian system attributes competence to single Regions. The seed stands were initially under the umbrella of Law no. 269 of 22nd May 1973, which regulated FRM trading and implementing the previous European Directive. The Legislative Decree 386/2003 increased the species and seed stand numbers.

In Tables 8.2 and 8.3 below, the annual quantity of seed collected, and parts of plants of the main forest tree species and other woody species are reported. It must be noted that this is an estimation on public forest nurseries.

Seed collections are generally preferred within seed stands, to keep high levels of variation, and cope with the great environmental heterogeneity characterizing the Italian peninsula. Concerning seed orchards, species, number of trials, generation and total area are reported in Table 8.4.

The commercialization of clones still concerns few other species beside poplars (Table 8.5, different species and hybrids), whose clones are registered in the National Register of Basic Materials in "controlled category", as defined by Legislative Decree 386/2003 (see Annex 1 of the Ministerial Decree 6 November 2015, n. 75568).

8.3 Grant schemes or other incentive mechanisms that promote the use of certain forest reproductive material

For species and artificial hybrids usable for forestry purposes (e.g., afforestation, reforestation, and hardwood plantations) considered by the Legislative decree 386/2003, it is possible to commercialize only certified FRM (article 3). In addition, the production, storage, trade, and distribution of this material are subject to the achievement of a specific license issued by the official control body. Even granting incentives for reforestation or other forest plantation is subject to the use of certified FRM. This means that for taking advantage of European incentives, the use of material certified according to 386/2003 and subsequent updates will be required.

Incentive mechanisms that promote the use of FRM can be funds for agricultural and rural development (PAC, PSR), structural funds, private funds (companies, foundations, associations, etc.), instruments relating to the ordinary and additional resources of the budgets of central and regional administrations for mountain and inland areas. Additional and complementary instruments of funding are the Community programs LIFE+ and INTERREG. Moreover, the use of market mechanisms based on economic incentives, the so-called payments for ecosystem services (Payment for Ecosystem Services - PES), has recently been introduced.

8.4 The role of registered seed stands, seed orchards and other sources in the supply of forest reproductive material

The importance of using FRM deriving from seed stands, seed orchards and other sources registered on the National List of Basic Materials (RNMB) is to provide certified basic materials and, consequently, avoiding inappropriate/unsustainable use of such material and to respond to current European and national legislation. According to them, basic material for forestry use must be accompanied by a certificate of origin/provenance or clonal identity (Annex VIII to the European Directive 1999/105/EC) from the seed collection site to the seedlings planting site. The certificate is issued by an Authority.

8.5 The supply of forest reproductive material and the demand in Italy

Currently, the supply of FRM does not fully respond to market demand. This impairing is probably caused by an important increase in demand due to new environmental policies (e.g., National Recovery and Resilience Plan), which have re-focused the attention on the multifunctionality of forests (natural, urban, and peri-urban).

It is worth noting that the drastic reduction of forestation and reforestation programs, caused by both the reduction of suitable areas and the reduction of incentives for the set aside of marginal lands, has determined a lack of interest in the forestry sector for about ten years. As a result, seed collections and FRM production have undergone a dramatic reduction. However, since 2003, the regional public forest nursery chains, especially the southern ones, have undergone a process of reform and rationalization that has made them adequate for the challenges that are being prepared for the coming years. The basic forest materials network has also undergone a significant boost and is ready to address future needs.

8.6 The trends in the demand for forest reproductive material

The introduction of urban and peri-urban forestry among forestry purposes, the preparation of programs to combat and mitigate climate change and the response to the exceptional climatic events such as the "Vaia" storm in 2015 in the Alps and the great fires of recent years suggest a growing trend in FRM demand for several hundred million seedlings over the next few years. An effort by the nursery chain is needed over the next 4 - 5 years to be prepared both in terms of quantitative production, genetic quality (e.g., suitable origins) and national coordination.

8.7 The information on forest reproductive material is certified for national (or sub-national) and international trade, and rules used for this purpose

The technical criteria and procedures for the control and certification of FRM for national and international trade are regulated by the OECD scheme for FRM and by national regulations for the implementation of European directive 1999/105 / EC and the Dlgs. 386/2003 (http://www.camera.it/parlam/leggi/deleghe/03386dl.htm).

The purpose of the law is to identify the criteria and technical methods for controlling the origin and certification of FRM through the following stages:

a) Criteria and technical procedures for the control of the provenance and certification of FRM.
b) List of additional tree species (article 1, paragraph 3, Legislative Decree no. 386/2003) subject to the same provisions as the species referred to in Annex I, Legislative Decree no. 386/2003.
c) Application for authorization for the production, conservation, marketing, and distribution of FRM pursuant to Legislative Decree no. 386/2003.
d) Application for renewal or replacement of the license for the production, conservation, marketing, and distribution of FRM, pursuant to Legislative Decree no. 386/2003.
e) Technical and economic report (to be attached to the license application);
f) License for the production, conservation, marketing, and distribution of FRM, pursuant to legislative decree no. 386/2003.
g) Loading and unloading register - tree species subject to the regulations provided for by Legislative Decree no. 386/2003, art. 5.
h) Producer tag - plants.
i) Producer label - seeds.
j) Model 6 - identification tag of the FRM in the field.
l) Communication for the collection of FRM, pursuant to Legislative Decree no. 386/2003.
m) Request for provisional authorization for the collection of FRM, pursuant to Legislative Decree no. 386/2003.

n) Notification of the collection of forest reproductive material and request for the "main certificate of identity", pursuant to Legislative Decree no. 386/2003.

8.8 Forest reproductive material exported and/or imported by Italy

The statistical data relating to the production, import and export of FRM are discontinuous and with relatively low quantities in Italy. Previously, the production of species produced *in vitro* or from cuttings, such as wild cherry or other precious woods, have dropped dramatically. In recent years, FRM production, in addition to being passed to a regional competence, has shown a significant increase in the number of species produced from seed, necessary to envelop the great environmental variability of the national territory.

8.9 The national (or sub-national) tree seed programme, how it is organized, and the main players and stakeholders

Italy has established forest genetic resources conservation strategies/programs since 1948. The first forest seed stand network was established by the Ministry of Agriculture in the 1950s (decree 30 March 1950) and registered in a national record, in collaboration with IUFRO and FAO [https://www.isprambiente.gov.it/contentfiles/00003500/3550-manuali-2003-18.pdf/].

Subsequently, in 1976, a network of biogenetic reserves was established in the framework of the European Council resolution 76/17 implementing the art. 4 of the Bern Convention of the European Council. Most of these reserves were also included in the National and Regional Protected areas Network. Then, implementing the national law 269/1973 EC and Directive 404/66 and the current OECD Forest Seed and Plant Scheme, the reserves were registered as selected seed stands in the National Seed Stand Book.

This network has been revised implementing the European Directive 1999/105/CE into the national Forest Decree 386/2003 and relevant regional laws or decrees, establishing a new national register collecting the regional register's information. Currently, Italian forest genetic resources conservation strategies/programs are included in the framework of the FAO International Food and Agriculture Genetic Resources Treaty, FAO Silva Mediterranea, IUFRO, EUFORGEN and European and National Conservation Programs and networks. The state and regional network of biogenetic reserves, national parks and other protected areas, and the seed stands network cover more than 30% of the national territory.

The national field network is articulated on 4 different levels and is aimed to support the supply of Forest Reproductive Materials following the requirement after the EU Directive 1999/105/CE and the OECD Scheme:

- Comparison between species.
- Comparison between provenances within species.
- Comparison of progenies and / or clones.
- Establishment of seed orchards.

Research and experimentation activities aim to identify the most productive and adapted materials and resistant/tolerant to adverse abiotic and biotic factors and preserve species or populations at high risk of genetic erosion if not extinction.

Broadleaved species belong to a broad range. They can be recorded by importance: poplars, chestnuts, wild cherry, walnuts, deciduous oaks, maple, ash, linden, elm trees, evergreen oaks, and other minor species. The selection and production of poplar clones is part of a long-time

agro-forestry tradition in Italy, particularly in the Po Valley, to produce pulp and timber. Moreover, poplars and willows are also currently employed in short-cycle plants for biomass and environmental restoration interventions with bioengineering techniques.

Broadleaves producing higher quality wood as walnuts, wild cherry, ashes, oaks, etc., were intensively planted in the last 30 years in forest tree farming, agroforestry, and reafforestation purposes.

To date, hardwoods preserved in *ex situ* collections for breeding or comparison and studies or materials of different origins are poplar, willow, walnut, cherry, elm, oaks, maple, ash, alder, rowan, beech, chestnut, wild olive, and others are starting to be considered or to be further studied especially in relation to the intended uses as part of the EU Directive 1999/105 / EC and Legislative Decree. n. 386/2003.

Research Bodies mainly deal with the improvement and selection of FGRs, while the Biodiversity Centers manage the collection, conservation, and distribution. As for the improvement and selection of *Salicaceae*, in addition to research bodies, some private companies also deal with it. For the main players and stakeholders see chapter 6 and 7 of the report.

8.10 The needs, challenges, and opportunities for increasing the use of forest genetic resources

- Increase the funding support for long-term management and monitoring of forest infrastructures to support and protect collections and field trials. This is important to ensure the sustainable use of forest genetic resources over time according to rigorous scientific criteria.

- Improve coordination among State and Regions and Research bodies and Universities

- A new forestry strategy that, with the view to conserve biodiversity and increase ecosystem resilience and services, contemplates the entire forest nursery chain from the identification and selection of the most suitable basic material in relation to the stationary conditions and future climatic scenarios, up to the planting site, with traceability of the entire path, for statistical and programmatic purposes (territorial / landscape management planning, for productive, protective, landscape, urban forestry, and recreational / tourist purposes).

8.10 The priorities for capacity-building and research

- Research on conservation programs related to global change effects.

- Capacity building at the regional level.

- Renewing resources with new campaigns.

- Improving coordination of the FRM production at the national/interregional level.

Chapter 9. The state of genetic improvement and breeding programmes[10]

9.1. The approaches used for tree improvement and breeding in Italy

Forest Genetic Resources (FGR) of Italy are adapted to diverse bioclimatic zones, which include the margins of distribution range for several species and for species at risk of extinction, such as *Abies nebrodensis* (Lojac.) Mattei (Ducci, 2011). This results in a high level of genetic diversity and a good raw material for genetic improvement (Falinski and Mortier, 1996). In addition, many species are characterised by high levels of intra-specific variance in neutral and adaptive traits, which makes selection of genotypes easier (Pâques, 2013).

Several approaches are used in tree improvement and breeding:

1. Plus tree selection.
2. Provenance trials and common garden studies
3. Controlled crosses and interspecific hybridization
4. Progeny testing
5. Clonal development

About 35 forest species have active programmes of improvement (Table 9.1). Breeding programmes exist for species of economic importance utilized in plantations for afforestation, reforestation, or commercial purpose. Some species have "Controlled Forest Reproductive Material (FRM)" with patenting or registration system. A recent Decree of MIPAAF has established the National Register of Forest Base Material (RNMB) (D.D. N. 307490, 6th July 2021 - Approvazione del Registro nazionale dei materiali di base). At present, the category "Controlled" of the RNMB includes 85 poplar clones and one cypress clone (pursuant to Legislative Decree no. 386/2003 and DD n. 307490, 06/07/2021, https://www.politicheagricole.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/17154), and only poplar clones are patented. The ONP is processing the registration of new clones of *Prunus avium*, *Castanea sativa*, *Ulmus* spp. and other forest species.

Poplars (*Populus* spp.) have an old tradition of breeding programmes, where the main objectives are survival and growth, disease and insect resistance, adaptability, crown architecture, and wood quality. In short rotation forestry (SRF), other additional goals are rapid juvenile growth, sprouting capacity after coppice, and density tolerance. Among other species, nine clones of *Cupressus* spp. (8 clones of *C. sempervirens* and 1 clone of *C. glabra*) were patented but not submitted for registration to the RNMB. The patented clones of *Cupressus* have been bred and selected for resistance to cortical canker. Other objectives of breeding in cypress are cold tolerance, canopy architecture and reduced production of allergens for ornamental purposes (AA.VV., 2010). Five clones of elm (*Ulmus* spp.) ('San Zanobi', 'Plinio', 'Fiorente', 'Arno' and 'Morfeo') were patented but not submitted for registration to the RNMB. In Italy, genetic improvement of elm started in the 1970s, mainly with the objective of resistance to graphiosis of the elm. As a multipurpose species, genetic improvement has also targeted plant shape, growth rate and wood quality. A strategy called "incorporation", with the infusion of local germplasm in breeding schemes, was applied in elm to maintain a high genetic

[10] This chapter was compiled by: Beritognolo I. CNR IRET, Monteverdi M.C. CREA FL, Proietti R. CREA FL, Sabatti M. UNITUS, Santini A. CNR IPPB, Vietto L. CREA FL, Nervo G. CREA FL, Ducci F. CREA FL.

diversity and adaptability of the improved plants (AA.VV., 2010). Finally, four clones of *Eucalyptus* have been submitted for registration to the RNMB.

9.2. Uses and traits prioritized in tree improvement and breeding

In forest species for artificial plantations, breeders have typically improved productivity and quality traits under stable climate conditions. However, climate change is ongoing and is associated with high meteorological variability and more frequent extreme events. To cope with the challenge of climate change, new breeding objectives have been identified, and adaptive traits of tolerance to climate disturbances have been targeted for selection (Ide, 2021; Matallana-Ramirez et al., 2021). Moreover, modern technological uses of wood biomass, as biorefinery, require specific wood features that are objectives of the new forest tree breeding programme (Moliner et al., 2021). The most common selection traits are (Table 9.3 and relevant literature box):

- Growth and tree form
- Wood quality
- Resistance to pest and pathogens
- Tolerance to abiotic stress (drought, early frost)
- Wood technological traits (including new uses, biorefinery)
- NWFP, Non-Wood Forest Product (according to the aim)

9.3. How tree improvement and breeding programmes are organized in Italy, and the main players and stakeholders

In Italy, the governance of the forest matter is the competence of different administrations. At the national scale, Coordination is performed by DIFOR. At the local scale, the 20 Italian Regions indicate the reference Authority responsible for producing and managing FRM according to the Legislative Decree 386/2003 and the EU Directive 1999/105/CE. For additional information about the policy and governance of FGR in Italy (see also subchapter 7.4).
Improvement and breeding of FRM are implemented by public and private organizations. National and regional technical bodies are also involved. Scientific and public research organizations are involved in genetics and breeding. Private growers and nurseries are also involved in breeding, mostly for *Salicaceae*.

The main players and stakeholders involved in tree improvement and breeding are:

- Public research organizations: Council for Agricultural Research and Economics (CREA), National Research Council of Italy (CNR), Universities, Regional R&D organizations.
- Centers for *ex situ* conservation and propagation of Forest Biodiversity (Centri Nazionali Carabinieri Biodiversità') are established at three sites: Pieve S. Stefano (AR), Bosco Fontana (Marmirolo, MA) and Peri (VR). These Centers are now managed by the Ministry of Defense through the Carabinieri Forestali, a branch of the Carabinieri, formerly State Forestry Corps now dissolved, and carry out activities to conserve FGR and produce FRM.

- The regional government of Piemonte supports the Regional Center of Chestnut ("Centro Regionale per la Castanicoltura del Piemonte", https://centrocastanicoltura.org/), which was established in 2009 for research and development on chestnut. In 2020, it was officially recognized by MIPAAF as the center for conservation and propagation of chestnut germplasm (Decree MIPAAF 20 November 2020). Moreover, Toscana Region protects the autochthonous genetic resources of several forest species (Regional Law 64/2004 Germplasm of Toscana Region), registered in a database (http://germoplasma.regione.toscana.it/) and conserved *in situ.*
- Each region manages a network of public Regional Forest Nurseries (Vivai Forestali Regionali) in charge of producing FRM for free distribution to public administrations, and commercial marketing to companies and citizens.
- The National Poplar Observatory (ONP) is a standing committee established in 2015 to overview the sector of commercial plantations of poplars and other fast-growing trees, with specific competence on registration of new varieties and clones in the "National List of Basic Materials" (RNMB) - Category "Controlled".
- Private companies: nurseries, seed traders, timber, forest products, mainly associated with commercial plantations of poplars. Poplar has an established tradition of genetic improvement in Italy, which involves private nurseries, mainly located in the Piemonte region.
- The network "Plant Genetic Resources" (RGV/FAO) has been established and funded by the Italian Ministry of Agriculture, Food and Forest Policies since 2000, in compliance with the FAO International Treaty on Plant Genetic Resources for food and agriculture. The network RGV/FAO involves several public research institutes (CREA and CNR) and the non-Governmental Organization "Rete Semi Rurali [*Rural Seed Network*]". RGV/FAO hosts the web portal PlantA-Res (http://planta-res.entecra.it), with a database of genetic resources of crops and forest species also used for the production of non-woody food and medicine products (e.g., chestnut, walnut, cherry, stone pine, etc.), with *ex situ* conservation programs.

9.4. Current and emerging technologies used in tree improvement and breeding

- Provenance testing by common garden field trials (most species).
- Mass selection of improved populations (*Cupressus sempervirens, Eucalyptus* spp., *Robinia pseudoacacia*, *Pseudotsuga menziesii*, *Prunus avium, Juglans* spp., *Pinus halepensis*, *P. pinaster*, *Ulmus* spp.).
- Selection of plus trees (most species).
- Progeny testing (*Alnus cordata, Cupressus* spp., *Cedrus atlantica*, Juglans spp., *Pinus halepensis, Pinus pinaster, Populus* spp., *Prunus avium, Pseudotsuga menziesii, Sorbus torminalis*).
- Recurrent selection *(Populus* spp., *Cupressus* spp., *Prunus avium, Juglans* hybrids)
- Controlled crossing (*Eucalyptus* spp., *Populus* spp., *Cupressus* spp., *Juglans* spp., *Salix* spp.).
- Interspecific hybridization (e.g.: *Cupressus* spp., *Populus* spp., *Ulmus* spp., *Eucalyptus* spp., *Juglans* spp., *Salix* spp.).
- Nursery techniques for quick clonal propagation (*Populus* spp., *Robinia pseudoacacia*).

- Grafting for breeding and propagation of clonal varieties (*Pseudotsuga menziesii*, *Abies nebrodensis*, *Juglans* spp., *Prunus avium*, *Castanea sativa*).
- *In vitro* culture for propagation and regeneration of recalcitrant species (*Prunus avium*, *Cupressus* spp., *Robinia pseudoacacia*).
- Biotechnological approach for selection assistance in breeding programmes (*Populus* spp.).

9.5. Tree germplasm quantities transferred within and outside of the country for research and development purposes

No standard procedures are available for recording and tracking germplasm transfer for research and development. Therefore, no official statistics are available for Italy.

9.6. Issues related to access and benefit-sharing

- To guarantee the conservation and access to plant genetic resources, in 1999, the Ministry of Agriculture and Forestry Policies (MIPAAF) launched the first national programme to safeguard the agricultural biodiversity of plant, animal and microbial genetic resources in Italian Regions and Autonomous Provinces (AAPP). A proper National Plan for Biodiversity of interest to Agriculture (NPAB) was adopted in 2008, and a Standing Committee on Genetic Resources (SCGR) was envisaged under the coordination of MIPAAF. This implies a long-term strategy for coordinating actions at the local level, with the aim of transferring information about genetic resources to local operators and stakeholders.

- "Nagoya protocol" on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity is the international agreement, which aims at sharing the benefits arising from the utilization of genetic resources. Italy joined this Protocol in 2011. This issue is under the competence of the Ministry for Ecological Transition (MATTM) (https://www.mite.gov.it/).

- Registro Nazionale dei Materiali di Base (RNMB), categoria Controllati [National Register of Basic Materials, Controlled category] (https://www.politicheagricole.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/17154
- Certificazione del Materiale di base, Dlgs. 386/2003 e successivi aggiornamenti [Basic Forest Material Certification, Legislative Decree 386/2003 and subsequent updates]. https://www.politicheagricole.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/16635

9.7. Needs, challenges and opportunities for tree improvement and breeding

Italy represents a hotspot of forest biodiversity but is particularly vulnerable to impacts of climate change. The challenge of tree improvement is to increase wood production without eroding the long-term adaptive potential or impairing the ability to supply the other needs of society. Continuous infusion of wild germplasm into breeding programmes is necessary to maintain a high genetic diversity and the resilience of plantations. Consequently, it is necessary to continue the characterization of natural genetic resources and expand *ex situ* collections and common garden trials to guarantee sources of new germplasm for tree improvement.

E*x situ* collections and long-term comparative field trials are crucial to obtain improved plant material for sustainable forestry. However, these research infrastructures are generally funded by short-term research projects and miss continuous support for long-term management and monitoring. International networks for comparative selection would greatly empower field trials.

New breeding objectives include environmental adaptability (drought tolerance and phenology) and tolerance to emerging pests. New technologies (i.e,, genomics, remote sensing, automated phenotyping) could accelerate tree improvement but their implementation in operational breeding requires a complex, integrated, and multidisciplinary approach.

Genetic improvement is a long-term process and needs continuity in breeding programmes and funding policy. On the contrary, in Italy breeding activities have been usually funded by short-term programmes (mainly EU programmes), with variable objectives and different target species. A National Forest Strategy was drafted by MIPAAF in 2019 and publicly distributed in 2020 to get feedback from stakeholders and citizens (https://www.politicheagricole.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/15339). This plan will represent the policy framework for conservation, management, and improvement of FGR.

9.8. Priorities for capacity-building and research in this area

- National strategy for long-term tree improvement and breeding
- Coordination of breeding activities at national and inter-regional scale
- Enhancing cooperation between the State and Regions and between Regions for shared species.
- Funding of long-term genetic improvement and conservation of FGR.
- Continuity of support for experimental infrastructures (field trials and laboratories)
- Enhancement of *ex situ* collection
- Strengthening the international networks for comparative evaluation and selection of improved FRM adapted to each geographic region.

Chapter 10. Management of forest genetic resources[11]

10.1. Genetic considerations taken into account, at practical level, in managing natural and planted forests, and other wooded lands, in Italy

The Management and responsible and / or sustainable use of FGRs is a fundamental aspect of forest management and therefore must be integrated with forest management policies and guidelines. However, still nowadays, in the culture of forestry technicians and policymakers, there is a tendency to underestimate the real importance of the genetic factor in adaptation and to properly manage FGRs.

[11] This chapter was compiled by: Camerano P. IPLA, Ducci F. CREA FL.

Ensuring sustainable use means maintaining or restoring the genetic integrity of populations and fostering their internal evolutionary dynamism to guarantee evolutionary adaptation for the future, especially considering ongoing climate change.
On the one hand, little attention is currently given to the genetic parameters that characterize forest populations that could instead direct management choices and strategies. Even less attention is given to the training of managers and to the disclosure by the scientific world in this sector. This minor training on FGR is also noticeable in environmental organizations except for genetic modified organisms (GMOs) or exotic species.
Despite this, for some time now, the working groups of some scientific institutions, especially CREA, CNR and Regions that operate on FGRs, have intensified their dissemination action among local administrations.
The FGR management in Italy is mainly addressed by the National Strategy on Biodiversity (Ministry of the ecological transition, MITE) and by the Legislative Decree n. 34/2018 (Consolidated Law on forests and forestry chains) which refers to the Legislative Decree n. 386/2003 (Forest Reproductive Material trade), implementing the EU Directive 1999/105/CE (Ministry of agriculture, food, and forestry policies, MIPAAF).
Through the definition of the aspects relating to the certification of forest multiplication materials, the management of forest genetic resources constitutes the basis of the regulation of the forest nursery sector starting from Directive 1999/105/CE. It plays an important role in the protection and management of forest biodiversity and in adaptation strategies to climate change. The traceability of forest reproductive materials, together with the correct identification, cataloging and management of basic materials, is a fundamental aspect for the development of the sector both nationally and internationally.
The management of FGRs takes place in Italy in two ways:

• evolutionary or dynamic, which pursues the conservation of the population (s) in such a way that the species can interbreed and select naturally

• static, where the conservation of existing genetic diversity is pursued, keeping the genotypes in the collection.

Depending on the location, these two modalities are carried out *in-situ* or *ex-situ* according to the following scheme (Table 10.1).

Information on FGRs is also an important aspect of their management. Several main databases exist in Italy at the national level, which contain GIS based lists of a huge number of records on Forest Basic Material (FBM). Many detailed databases exist at the regional level, either referring to FGRs included in protected areas networks (MITE, 2021), either finalized to FBM and FRM management (MIPAAF, 2020). At the national level, the National Register of FBM must be mentioned, which summarizes the whole regional database system (approved with D.D. N. 307490 of 06/07/2021).

Another Record exists for forest FBMs of species relevant to the Vegetal Genetic Resources for food implemented by MIPAAF for the FAO International Treaty on Plant Genetic Resources for Food and Agriculture, namely Planta Res (CREA, MIPAAF).

At the international level, information of *in situ* or planted materials is available within the databases of international EU projects as Treebreedex and Trees4Future (http://www.trees4future.eu/transnational-accesses/treebreedex.html),

Eufgis (http://portal.eufgis.org/) and FAO - Silva Mediterranea WG4 (http://w3.avignon.inra.fr/ForSilvaMed/) .

10.2. The current and emerging technologies used in the management of forest genetic resources in Italy

Ultimately, the legislation indirectly refers to the management tools already in force in forestry and environmental matters.
Besides implementing the Legislative Decree 386/03, the TUFF delegates the management of FBMs and FRM to the individual regions; it does not explicitly refer to the *in-situ* management of RGF, except by referring to management regulations to be integrated with forest and environmental planning at the regional level.
At the regional level, the legislative landscape is varied, as can be seen at Table 10.2.
Some considerations can be made from the table:
• Transposition of European and national legislation. Most of the Regions have implemented Legislative Decree 386/03, except for Val d'Aosta and Liguria, although in the latter there is a list of seed forests in compliance with EU Directive 1999/105/CE; in all regional forest laws, except for Val d'Aosta, the issue of forest nursery is addressed as a fundamental tool for the management of certified autochthonous forest materials.
• Forest Genetic Resources. In most of the most recent regional regulatory measures, the issue of biodiversity conservation is generically cited. However, there is no connection with the forest as a genetic resource and that the "seed woods" represent the areas of the greatest importance which, together with forest nurseries, represent the operational tools for the FGR management.
• Management regulations and specific interventions. The issue of managing FGR in relation to traditional forms of governance and treatment is addressed in the laws of Piemonte, Lombardia, Toscana, Lazio, Marche, Abruzzo, Campania, Molise, and Sardegna and in the implementation of legislative decree 386/2003. In both cases, the legislator wanted to pay attention to the need to draw up specific management tools, forms of governance and treatment or specific interventions, in Piemonte for example this provision states "*the methodologies for the preparation of specific forestry plans for seed populations and for the stipulation of agreements aimed at their conservation and enhancement*".
In all other cases, the legislator does not deal with defining specific forest management, but indirectly delegates the planning tools in force and the sensitivity of the planner, but always within the context of traditional forms of governance and treatment.

Therefore, the regulatory instruments at the various levels pay particular attention to the forest nursery chain as the main tool for FGR managing, neglecting an explicit reference to forest management models.
This aspect is currently becoming particularly significant in relation to the abiotic threats and damage due to climate change.
However, by addressing the issue of ecosystem services provided by the forest, the TUFF indirectly supports the concept of FGR as an ecosystem service and sets the general objectives of sustainable forest management.
Although there are no data on the impact that the different forms of governance and treatment have on intra-population genetics, there is a consensus to favor the creation of multi-age and multi-specific stands, at least for groups of different sizes, avoiding an excessively contemporary structure on large surfaces.
Concerning coppice systems, a management solution that, above all, would make it possible to guarantee the conservation of sporadic or less widespread species would be the compound coppice, the latter to be understood as a mixture of coppice and high forest for groups, preferably non-biplanes.

All regional and local level regulations set a "minimum rotation" for coppices of various species to prevent the negative consequences of this. There are profound differences among the Regions also about the same species in the same biogeographical context. For example, the minimum rotations for beech vary from 20 years (Basilicata, Friuli Venezia Giulia, Lombardia, Piemonte, Sicilia, etc.) to 30 years (Trentino-Alto Adige). For oaks, some regions distinguish between deciduous and evergreen oaks, while in other cases, a minimum rotation is indicated for oaks in general, without distinction of species. Not all regions have identified a "maximum rotation" and with it an age range within which the use of coppice can be considered unequivocally and fully compliant with the cultivation criteria.
As regards the protection of diversity, specific reference is made in the regulation of the Regions of Calabria, Piemonte, and Toscana to the release of sporadic species that must be safeguarded. In the Forestry Regulations of Toscana, explicit reference is made to the so-called "tree silviculture": in this case, the cuts are aimed at the protection and enhancement of individual trunks of sporadic tree species, also recognizing in the coppice target trees that are favored in spatial relationships and breeding than competitors. Finally, in the Regulations of Lazio and Umbria, reference is made to the release of trees to be used for indefinite ageing, to be selected from those of greater age and size present in the area affected by the cutting of the coppice.
The introduction of the parameters for coppices management aims at improving the ecosystem service "FGR", in the context of silvicultural interventions referable to traditional silviculture. The customary rotations are in fact regulated to obtain the maximum incremental development and the species of interest, beyond which it is no longer convenient to let the plants grow; on the contrary, the production of seed for many species begins precisely in correspondence with the physiocratic rotation (i.e, oaks reaching maturity between 80 and 100 years, the average shift varies between 150-200 years for the high forest and 35- 40 for the coppice). The production of wood needs to make the subjects grow at higher densities than in natural conditions, in order to obtain individuals with small foliage, carried in the upper third of the trunk with no branches in the lower part of the trunk; on the other hand, good seed production is guaranteed by subjects with large and branchy foliage, in full light, even with a non-exceptional phenotype; to achieve this, it is necessary to greatly reduce the density of the stands with very intense free thinning.

10.3 Specific management interventions

Regarding possible interventions financed through the Regional Development Programs (RDPs), several Regions have activated measures to improve the ecological stability of the forests; only Piemonte with the RDP 2000-2006 has activated the specific Measure I7 on seed forests.

Local FGR (or other FBMs) management regulation plans - minimum shared contents
An important tool for controlling and managing forest genetic resources is the management disciplinary, which has been up to now neglected in most cases and foreseen by the regulations only for seed stands. Instead, it is very important to give value to this technical document and that its drafting and application in the legislative field be mandatory for all types of basic materials. It can become, in fact, the main instrument for ensuring the dynamic perpetuation of FGRs and control over their correct use.

Stands, populations and seed collection areas
The disciplinary for the management of stands, populations, and seed sources must not be considered a simple management plan as for any forest.

It is drawn up based on the technical information collected during the filing of the material itself for registration purposes and provides a series of precepts and observations, which establish and direct the cultivation activity to ensure the best preservation of the FGR with a dynamic criterion.
Homogeneous treatments on wide surfaces must be avoided, the genetic and structural dynamics of the seed populations must be observed over time, and the interventions must be flexible and adapted to the needs of the different species.
On the one hand, in fact, it is necessary to maintain a structure of the forest capable of favoring the production of seeds; on the other hand, it is necessary to consider the ecological needs of the species in the adult layers and in the renewal phase. Finally, it is necessary to maintain specific and genetic diversity to guarantee all the natural processes that determine the evolution of the population itself.
The management specification must also make use of information deriving from the application of genetic investigation methods to monitor, at least at an indicative level, the evolution of the genetic structure and consequently adopt the cultural decisions necessary to preserve the evolutionary dynamics of the population.

Other basic materials
A management specification must also be established for base materials other than those mentioned above as seed orchards, parental (or parent) plants, clones, and mixtures of clones, and genetically modified organisms (GMOs). For them, the site of origin and where the basic collections are kept must be indicated, as well as plans and methods of maintenance and their rejuvenation, duration of conservation and, in the case of seed orchards, an estimate of the main genetic parameters (homozygosity, percentage of polymorphic loci, fixation indices, etc.) with respect to the mean of the species and any useful observations to understand its traits.
Any pruning to be applied and / or other techniques (girdling, constriction, hormonal treatments) suitable for inducing flowering, as well as the production cycles of the seed and pollen must also be indicated. Furthermore, in the introductory part of the management regulations, the following must be indicated:
1) for seed orchards:
- type of arboretum (clonal, seedling, mixed between these two types)
- adopted intersection design and map with the arrangement of the different materials.
- number and list of the different components (clones or families);
- year of establishment.
- region of provenance and origin of the components (clones or families).
2) for parents:
- number and consanguinity of parents.
- proportion of each component family in the mixtures.
- crossing design adopted.
- region of origin and origin of each parent.
3) for clones:
- clonal pedigree (ortet and / or family of origin of the ortet)
- selection criteria and method.
- region of origin of the clone.
4) for mixtures of clones, the following are added to the indications of point 3:
- number and list of components clones.
- proportion of each component clone.
5) for GMOs, the indications of point 3 apply and:
- type of modification induced and the methods used.
- techniques to control the gene (s) introduced or modified.

- the authorization to place material on the market must also be attached, as well as a report on the biological and environmental impact drawn up in the manner provided from art. 5 of Directive 1999/105/EC.

Silvicultural management for a stand suitable for seed procurement must be based on the following assumptions:

1. length of shifts very close to the natural ones of the species in order to fully exploit the productive period: in the first years of fruiting, as for senescent trees, the produced amount, and the quality are scarce and irregular.

2. the densities must be very low to guarantee the maximum surface of the canopy with good or excellent lighting; furthermore, to facilitate the collection of seed, it is necessary that the lower arboreal and shrubby layers are not present. In this regard, it should be noted that the density conditions are not the same for all species but must be defined individually.

The methods and types of management intervention depend on the evolutionary-cultural structure or the structural type. The following table indicates the minimum number of seed carriers that should be present per hectare for some tree species.

Species Minimum number of mother trees per hectare
Beech 40 - 60
Oaks 30 - 50
Fir trees 60 - 100
Pines 60 in regular high forest, 30 in irregular high forest
Mesophilic deciduous trees 80 - 100
Sporadic deciduous trees 20 - 40

Considering these values, based on the different cultural evolutionary situations and the previous silvicultural interventions carried out in the stands and woods identified as suitable for seed collection, two types of silvicultural objectives and, therefore, of interventions can be outlined:

1. populations currently suitable for harvesting for certain species, with numerous sources of seed, whose productions are qualitatively and quantitatively satisfactory. In this case, the short and medium-term silvicultural objectives are aimed at maximizing seed production, keeping it constant, making harvesting conditions easier with specific interventions (release of seed trays, crop care, clearing of the undergrowth, etc.).

2. populations currently unsuitable for harvesting, with subjects of excellent phenotype but poorly fructified due to the presence of:
• subjects too young, with age below that of maturity for fruiting: this is the case of some populations of beech deriving from active or natural conversion to high forest.
• seed-bearing subjects with good phenotype, but in evolutionary-cultural conditions not suitable for harvesting and fruiting: this is the case of some very dense broad-leaved stands, with individuals with small foliage, placed at a considerable height from the ground.
• sporadic individuals, located in the lower arboreal or shrubby plane: this is the case of many minor fruiting Rosaceae and most of the shrubs, which although always present only rarely can bear fruit. In this second case, the silvicultural objectives are aimed at identifying the individual nuclei of seed carriers and, secondarily, create the ideal conditions for their growth and fruiting,

through widespread interventions on large surfaces (thinning, often mixed with variable intensity conversion, planned renewal of the stand, etc.). All the treatment interventions of traditional forestry refer to this category of interventions, apart from coppices.

Based on the above, the main types of intervention envisaged are the following:

1. Thinning / conversion to high forest in simple or compound coppice to favor the development or maintenance of seed carriers with deep foliage of the builder species of the stand (oak woods, beech, ash, and alder woods, etc.): this intervention includes thinning by the layer of high forest or freed persons and the contextual cut of conversion of the coppice component in populations with previous mixed governance, sometimes with an irregular structure. As far as conversion is concerned, the methods to be used refer to both the starter cutting method and the one with selective thinning by cells. The intensity of the individual interventions is established by the specification.

2. Highlighting of sporadic species by freeing them from competitors with thinning on the dominant level (*Rosaceae*, lime trees, etc.), even if they are promising and good value subjects.

3. Containment of the undergrowth to facilitate the practicability of the land and the collection from the ground (oak, beech): the intervention consists in eliminating a large part of the shrub vegetation, repeatedly passing in the case of species with excellent sucker capacity.

4. Preservation of shrubs by highlighting them to promote fruiting: the intervention consists in identifying the main groups of shrubs, eliminating the arboreal vegetation placed in the vicinity that limits the arrival of light.

5. Pruning and pollarding to increase production and favor harvesting.

10.4 The main actors/ stakeholders for managing natural and planted forests, and other wooded lands at national (or sub-national) level

The TUFF, as already said, delegates the management of FBMs and FRM to the Regions (Table 10.2); also in this case it does not explicitly refer to the *in-situ* management of RGF, except by referring to management regulations to be integrated with forest and environmental planning at regional level.

10.5 The needs, challenges, and opportunities for improving the management of forest genetic resources in Italy

The TUFF, introducing the concept of ecosystem services, places among its general objectives to favor the sustainable and multifunctional management of forests, guaranteeing the protection of the diversity of species, both in terms of habitat and genetics. It is necessary to combine the national forestry strategy (Article 6 paragraph 1 of Legislative Decree 34/2018) with a national strategy for the protection of forest genetic resources and forest nurseries. This document, in addition to providing an overview of forest genetic resources, must address the following issues:

- define conservation, management, and monitoring programs

- identify the structures interested in the conservation and management of RGF (partially met by the lists of Forest Biodiversity Study and Conservation Centers (MITE and MIPAAF, Decree in preparation).
- define current and future threats
- define management guidelines for the conservation and improvement of forest genetic resources
- identify standard management disciplinary models with minimum shareable information requirements
- define forms of dissemination and training for operators in the sector.

10.6. The priorities for capacity-building and research

The following priorities are hoped for:

- identify silvicultural and management forms that increase the genetic diversity of species.
- homogenize and harmonize the various forest management regulatory measures of Regions.
- provide indications for enriching forest planning tools suitable for the conservation of FGRs.
- promote certification processes for sustainable and responsible forest management that protect the genetic diversity of species.

Chapter 11. Institutional framework for the conservation, use and development of forest genetic resources[12]

11.1 National coordination mechanism on forest genetic resources (FGR), how it operates, and its structure

The coordination of the management of FGRs is one of the tasks of the General Directorate of Mountain Economy and Forests (DIFOR) established near the Ministry for Agriculture, Food and Forestry Policies. The Legislative Decree n. 34/2018 stated a Technical Commission to improve coordination mechanism for the sub-national competent offices and define some decrees and guidelines regulating many aspects of management and use of forest genetic resources, with particular attention to the forest reproductive material. To improve the traceability of the FGRs, an information system that also allows the movement of reproduction materials to be recorded is being discussed. Now there is an updated list based on the communications of the competent regional offices. This list is flown into the FOREMATIS system made available to Member States by the European Commission.
At the national level, there is a Technical Commission established by the Decree Dlgs. 386/2003 and the National Observatory on Poplar and Forest Tree Species clones which coordinates the activities in this specific field. The Observatory is also in charge of new clone evaluation in the framework of 386/2003 Decree. The Technical Commission, established by the inter-ministerial decree no. 12077 of 11 December 2018, began addressing the issues of production and marketing of forest reproductive material. The activities on FGR management and conservation are mainly delegated to regional administrations under the umbrella of the legislative decree 386/2003, which implements the EU Directive 1999/105/CE. The aim of the national authority, the DIFOR of MIPAAF supported by the Technical Commission, is

[12] This chapter was compiled by: Ducci F. CREA FL, Librandi I., DIFOR, Pompei E. DIFOR, Scarascia Mugnozza G. UNITUS DIBAF, Vendramin G.G. CNR IBBR.

coordination and guidance in main activities, at the national level, and the connection with the UE Commission and the other EU Member States. FGRs are also considered by the national Biodiversity Strategy, whose Authority is MITE (https://www.minambiente.it/sites/default/files/archivio/allegati/biodiversita/estratto_strategia_eng.pdf) and by the Consolidated Text on forests and forestry chains (TUFF, Legislative Decree 3 April 2018, n. 34 Law on forests and forestry chains, https://www.gazzettaufficiale.it/eli/id/2018/04/20/18G00060/sg) .
The Ministry Decree no 9403879 of 30 December 2020 stated some minimum common admission requirements for the basic material, already belongs to regional Lists, to national register and give some indication for certification to improve traceability of forest reproductive material.

11.2 The main institutions and stakeholders involved in the conservation, use and development of forest genetic resources in Italy

The General Directorate of mountain economy and forests (DIFOR) of MIPAAF; Ministry of the ecological transition (MITE); CREA, Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria; CNR, Consiglio Nazionale delle Ricerche; Universities (Ministry of Instruction and Research); ISPRA, Istituto Superiore per la Protezione e la Ricerca Ambientale; ENEA, Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile, Study centers for forest biodiversity (former Seed Centers) of Carabinieri Forestali - Ministry of defense; Regions, Istituto per le Piante da Legno e l'Ambiente (Institute for woody plants and the environment, IPLA-Spa) .

11.3. How different stakeholders are involved in decision-making related to FGR management

DIFOR coordinates the 21 Regional Authorities and supports the National Committee for FRM (art. 14, Legs. Decree n.386/2003) where research institutions, and representatives of State and Regional authorities, and private producers' organizations are represented. The DIFOR draw and give shared guidelines and Ministry Decrees for technical issues at national and international level. The Technical Commission support the Ministry in these activities. Regional authorities are main competent in decision-making on forestry sector, according to national law and EU directives.

11.4. Specific policies and strategies on forest genetic resources

The national strategy for FGR is based on the European Strategy for Forests, the National Strategy for Biodiversity, and the EU Directive 1999/105/CE on the production and deployment of FRM. All these three tools are narrowly integrated into the joint activities of both MIPAAF and MITE.
In confirming the national commitment to achieve the European goal of halting the loss of biodiversity by 2020, the National Biodiversity Strategy is a tool for integrating the conservation needs and sustainable use of biodiversity into national policies, to its intrinsic and tangible value and the importance of the ecosystem services deriving from it, which are essential for human well-being.

From these considerations derives the vision for the conservation of biodiversity of the National Strategy: "*biodiversity and ecosystem services, our natural capital, are preserved, valued and, as far as possible, restored, for their intrinsic value and so that they can continue to support*

economic prosperity and human well-being in a lasting way despite the profound changes taking place at global and local levels".

For its achievement, the National Strategy is articulated around three key themes: biodiversity and ecosystem services, biodiversity and climate change biodiversity and economic policies.

The species included in Annex I of the European Commission (EC) Directive 1999/105/CE and in the Legislative Decree 386/2003 are primarily considered. However, Regional and / or Autonomous Provinces Lists may include other species of local interest.
In addition, the Law 394/91 (Official Gazette https://www.gazzettaufficiale.it/eli/id/1991/12/13/091G0441/sg) on the establishment and management of protected areas in Italy must also be considered, implementing the broader constitutional principle of protecting the environment and ecosystems. Most of FBMs as the registered seed stands are indeed included within protected areas.

11.5. Specific legislation and/or regulations developed on forest genetic resources

These aspects are indirectly addressed by the Legislative Decree 386/2003 and relevant legislation by Regions and by TUFF (2018). Drafting the Ministry Decree no 9403879 of 30 December 2020, the Technical Committee has undertaken other activities relating to the regulation of the use of FRM in forestry interventions and the study of systems to improve traceability and data collection.

11.6. Specific legislation or regulations on forest genetic resources

Based on the Technical Commission proposals and taking account of the EU Biodiversity strategy for 2030, the National Register of Forest Basic Materials and common minimum admission criteria were established by the MIPAAF Decree 30th December 2020 no. 9403879.

11.7. The state of research and development on forest genetic resources in Italy

Research on FGRs is run in Italy by CREA, CNR and Universities, while development is generally performed by regional institutions (Table 11.1).

- *CREA FL, Arezzo, Casale Monferrato, Roma, mission*

FGR can supply forest, medicinal, aromatic, nutritional and therapeutic benefits but are nowadays coping with the effects of environmental changes. In this perspective, the genetic structures of forest species must be monitored in the long term, with particular attention to the peripheral and marginal ones and those at risk. Supporting and improving wood production is a highly topical issue in forestry research, with reference to innovative approaches in plant genetics.
Equally important in Italy is the scientific support given to the national forest nursery system and the relevant legislation, which have a crucial role in the improvement and the management of forest genetic resources, the adaptation of forest tree species to climate change effects in the Mediterranean context and the forest restorations after catastrophic events related to climate change and increasingly frequent in recent years, such as forest fires and storms.
Related to this topic are research and long-term experiments on assisted migration techniques. Another important aspect also concerns the mitigation in peri-urban areas.

Poplars, noble hardwoods, and conifers for wood production are objects of genetics and breeding research and experimentation and *ex situ* conservation.
Pending the implementation of Legislative Decree 386/03 and Directive 1999/105 / EC) and its integration into the Consolidated Forestry text (TUFF), an inventory of *in situ* and *ex situ* Italian FGRs, current research and experimentation on the main investigated species was carried out and published in the form of a database and in hard copy. The database, owned by CREA FL, was realized in the framework of national research programmes as RGV-FAO International Treaty for Plant Genetic Resources for Food and Agriculture, RiSelvItalia; EU international projects as TREEBREEDEX, TREES4FUTURE, and BE4EST; and in networks as EUFORGIS and FAO Silva Mediterranea WG 4.
Concerning CREA FL, the *ex-situ* collections in Arezzo, Rome and Casale Monferrato were recorded.
Part of this database is published on the MiPAAF websites :
http://planta-res.politicheagricole.it/pages/specie_gruppo.php?gr=3
Part is included in the EUFORGEN / EUFGIS database:
http://portal.eufgis.org/search/simple/list/?tx_wfqbe_pi1[country_name]=Italy

- *CNR IBBR, Sesto Fiorentino-Firenze, mission*

Analysis of genetic variation using molecular markers (ESTs, SSRs, SNPs, etc.) in forest species, with reference to the genetic structure of populations, phylogenetic relationships, gene flow within and between populations, the mapping of existing gene pools, and the mechanisms of maintenance in nature of genetic variation and adaptive potential.

Study of the adaptive mechanisms of forest species and response to abiotic and biotic factors. Identification through next-generation sequencing techniques of candidate genes (e.g., SNPs) involved in the processes of adaptation / selection of forest species to the main environmental factors. Investigations aimed at identifying genotype-phenotype associations *in situ.*

Analysis of the risk associated with the introduction of genetically modified trees, by modeling the possible impact on existing biodiversity of the release of transgenes into the environment via gene flow, and of possible environmental impacts by analyzing gene contamination in model systems.

Study of the biochemical and eco-physiological responses of plant genotypes to biotic and abiotic stresses aimed at identifying secondary metabolites (volatile terpenes) as markers of resistance to attack by pathogens and parasites. Analysis of the ecological role of the emission of volatile organic compounds (VOCs) in response to environmental stress. Investigations aimed at identifying the eco-physiological mechanisms of response to water stress and to the variation of the light environment.

In vitro propagation of forest species for the selection and maintenance of valuable genotypes (micropropagation, organogenesis, somatic embryogenesis) and for applications in the agro-food and pharmaceutical sectors. Analysis of the tolerance to heavy metals of species cultivated in vivo and *in vitro* with a view to phytoremediation activities.

- *CNR IRET, Porano (Terni), mission*

The scientific mission of IRET is to carry out fundamental and applied research activities across its offices on the following main issues:

Population genetics, gene conservation, ecological genetics and genomics of forest and fruit tree species.

Interactions between plant species and the environment.

Effects of anthropic interventions on ecological balances.

Biological and evolutionary processes and mechanisms in plants in relation to the environment.

Ecophysiological mechanisms and productivity of agricultural and forest plants.

- *CNR IPSP, Sesto Fiorentino-Firenze, mission*

Stress factors (biotic and abiotic) and the consequent responses of plants are studied to identify resistance mechanisms, adaptation processes. Methods of protection from stress are studied that contribute to the protection and enhancement of plants of agricultural and forestry interest. The institute also studies the enhancement of natural antagonisms, and biocontrol methods of plant parasites, the qualitative, and quantitative improvement of agri-food production, and the selection and recovery of valuable plant germplasm. The characterization and production of bio-molecules of agro-industrial interest, the mitigation the impacts of global change and sustainable and environmentally friendly growth are also interests of CNR IPSP.

- *University of Florence, UNIFI, dept. GESAAF, mission*

Long tradition was formerly developed near this faculty on forest tree breeding and improvement. Nowadays, all these aspects are treated in the framework of Agricultural Genetics. A Seed Analyses Laboratory operates for official testing on forest seeds.

- *University of Tuscia, UNITUS, dept. DIBAF, Viterbo, mission*

Genetics, Breeding, conservation, and improvement of Mediterranean forest tree species, Ecophysiology for adaptation, and research related to the identity of legal wood trading are the main research fields of this department. Breeding and improvement of *Populus alba* and relevant collections are maintained there.

- *University of Parma, UNIPR, dept. of Chemical Sciences of the Life and of the Environmental Sustainability, mission for FGRs*

Concerning genetics applied on FGRs, evolutionary biology and ecology represent an integrated research area for the study of biological diversity and its evolution, the behavior, and relationships of living beings, including humans, with each other and with the environment.

Research ranges from the molecular level to that of the organism, population, and community. Great importance is given to the use of innovative biostatistics methods.

11.8. The state of education and training on forest genetic resources in Italy

Here below is the description of the Forest Science teaching situation. Genetics and FGR related topics are included within:
"*A greater consideration of the multifunctional role of forests that had to lead, after the Rio Conference on the environment, at the recognition of the key role of forests for the survival of populations. This event has a positive influence on forest education and so there is a new interdisciplinary curriculum taught in many University Departments. Since 1999, in Italy, in addition to the traditional four/five-year degree, a bachelor's degree and a master's degree have been introduced to facilitate a more rapid entry of students into the labor market. After the application of* a recent *law with the abolition of the faculties and teaching entrusted to the Departments, the Forestry Education results very fragmented and only partially fulfills the requirements of the labor market. It would be desirable to overcome the general uncertainty by the realization of the meeting among the stakeholders of the forestry and environmental sectors"* (from Giordano and Recanatesi, 2015).
It is noted a loss of competences on this field by foresters which are progressively substituted by and generally not integrated to biotechnologists. This situation will be reflected when graduated will be in policymaker positions with a lower sensibility towards FGR problems.

Teaching related to FGR is carried out at the following Universities:

- Università degli Studi di Torino, included within Agricultural Genetics
- Università di Firenze – GESAAF, in 2009 a course on "Molecular techniques applied to the genetic improvement of forest trees" was activated. Nowadays, some relevant courses are spread in different dept.s and curricula as: Genetics and environmental genomics, Silviculture and Genetics etc.
- Università della Tuscia, Centro Studi Pieve Tesino - Genetic resources of high-altitude marginal tree populations
- Università della Tuscia – DAFNE - Conservation of biodiversity and forest genetic resources
- Università degli Studi di Sassari - Genetics of Forest Systems
- Università degli Studi di Pavia - Laboratory of Plant Ecology an Biological Conservation
- Università degli Studi di Parma – Chair of Population biology

Masters

Università della Tuscia – DEB - Conservazione della biodiversità e delle risorse genetiche forestali

11.9. Needs, challenges and opportunities for strengthening the national (or sub-national) institutions and policies on forest genetic resources

Needs concern the improvement of communication and access to information. Better communication can increase the citizen interest in studies of forest genetic resources, it can also stimulate the interest of decision-makers that can influence the state and management of resources.

The challenges are to improve a coordination system that ensures a correct data flow between national and sub-national institutions and, at the same time, optimizes protocols for a minimum administrative burden.
The opportunities are related to public awareness of biodiversity and to the need of planting new forests also by institutions and associations. The protection of forest genetic resources requires the correct use of the forest reproductive materials, based on planning and studies on the matter, most suitable for current and future environmental conditions.

11.10. Priorities for capacity-building in this area

- Creation of a network between national and sub-national authorities and research bodies involved.
- Reorganization of the collection and storage of available data.
- Regulating rights on data ownership and use of FGR.
- Restoring teaching of Forest tree breeding and improvement in the University curricula.

Chapter 12. International and regional cooperation on forest genetic resources[13]

12.1 International and regional projects on forest genetic resources Italy has been, or is, involved in since 2013

The main objective of international and regional projects is to provide data and indices that describe genetic and phenotypic properties of forest tree populations and genetic resources to preserve forest germplasm, as well as its expected responses to environmental challenges. Such information will facilitate conservation programs and help to identify the best-preserved germplasm to be used in reforestation activities and breeding programs. Italy has participated in the following research programs since 2013.

- International programs funded by EU

1. TREES4FUTURE - "Designing Trees for the future" funded by the EU under FP7-INFRASTRUCTURES (2011 – 2016) Grant agreement ID: 284181.
2. COST Action FP1202 (20012 – 2016), "Strengthening conservation: a key issue for adaptation of marginal/peripheral populations of forest trees to climate change in Europe" (MaP-FGR), COST-Action funded by the European Union. Grant agreement ID: 676876
3. PROCOGEN - "Promoting a functional and comparative understanding of the conifer genome- implementing applied aspects for more productive and adapted forests" funded by EU under FP7-KBBE (2012 – 2016) Grant agreement ID: 289841
4. LIFE RESILFOR, Natura 2000, (REstoring SILver-fir FORest) LIFE08 NAT/IT/000371
5. FORGER - "Towards the Sustainable Management of Forest Genetic Resources in Europe" funded by the EU under FP7-KBBE (2012 – 2016) Grant agreement ID:

[13] This chapter was compiled by: Sabatti M. UNITUS DIBAF, Beritognolo I. CNR IRET, de Dato G. CREA FL, Vendramin G.G. CNR IBBR, Marchi M. CNR IBBR, Pompei E. DIFOR, Scarascia Mugnozza G. UNITUS DIBAF, Ducci F. CREA FL

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6. GenTree - "Optimising the management and sustainable use of forest genetic resources in Europe", funded by the EU under H2020-EU.3.2. (2016-2020) Grant agreement ID: 676876
7. B4EST – "Adaptive BREEDING for productive, sustainable and resilient FORESTs under climate change" funded by the EU under H2020-EU.3.2.1.4. (2018-2022). Grant agreement ID: 773383
8. GenRes Bridge – "Joining forces for genetic resources and biodiversity management" funded by the EU under H2020-EU.3.2.1.1 Coordination support Action. (2019-2021). Grant agreement ID: 817580
9. FORGENIUS - "Improving access to FORest GENetic resources Information and services for end-USers" funded by the EU under H2020-EU.3.2.1.1. (2021-2025). Grant agreement ID: 862221
10. LIFE AFORCLIMATE - "Adaptation of Forest management to Climate variability: an ecological approach" funded by the EU under LIFE15-CCA-IT-000089. (2016-2023).
11. LIFE SySTEMiC – "Close-to-NAture Forest sustainable management practices under climate changes" funded by the EU under LIFE18 ENV/IT/000124. (2019-2024).

- **International bilateral projects funded by Italy**

1. "Tree fragmented populations from refugial areas: the anfiadriatic connection", CNR MoS - Bilateral Project Italy/Montenegro (2015-2016)
2. "Adaptive responses to drought in *Pinus heldreichii* along altitudinal transect in the Apennines and the Balkans", CNR MoS- Bilateral Project Italy/Montenegro (2017-2018)

- **National Projects**

1. "Conservazione *in situ* del germoplasma di pino loricato. Azione 1 – Indagini genomiche ed ecofisiologiche: adattamenti ai cambiamenti climatici del pino loricato" [In situ *conservation of Bosnian pine germplasm. Action 1 - Genomic and ecophysiological investigations: adaptation to climate changes of the Bosnian pine*], Parco Nazionale del Pollino (2016) and "Conservazione *in situ* del germoplasma di pino loricato. Azione 2 – Studio della variabilità genetica adattativa" [*In situ* conservation of Bosnian pine germplasm. Action 2 - Study of adaptive genetic variability], Parco Nazionale del Pollino (2017).
2. "Indagine su provenienza genetica e livello autoctonia dei popolamenti artificiali di *Abies alba* presenti nel territorio del Parco Nazionale della Majella" [*Investigation of the genetic origin and autochthonous level of the artificial populations of Abies alba present in the territory of the Majella National Park*], Parco Nazionale della Majella (2017).

1. "LIFE 14 IPE IT 018 - GESTIRE 2020 "Una nuova strategia integrata per Rete Natura 2000" [*A new integrated strategy for Natura 2000 Network*] (2016-2023). ERSAF Servizi di assistenza tecnica in ambito forestale per la definizione di criteri e linee guida

nella gestione dei querceti lombardi" [*ERSAF, Technical assistance services in the forestry sector for the definition of criteria and guidelines in the management of Lombard oak forests*]. LIFE IP project, Gestire 2020 - Azione A.18 e C.14. Contract n. 2019/23843 (2019-2021)

2. "Fondazione con il sud - L'ultima foresta incantata" [*Foundation with the South - The Last Enchanted Forest*]. Bando Ambiente 2018. Project code: 2018-AMB-00138 (2019-2022).
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4. Vegetal Genetic Resources – FAO International Treaty on Agriculture Genetic Resources (MiPAAF), 2004-2021, (http://planta-res.politicheagricole.it/pages/institutes.php), conservation and research activities were funded on stone pine, Chestnut, Birch, Douglas fir, Sicilian fir during different funding cycles.
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8. DUS (Distinctness, Uniformity and Stability) Tests on *Eucalyptus* sp. – Funded by CPVO (Community Plant Variety Office), (2018-2021).

12.2 How Italy benefited from the international and regional cooperation on forest genetic resources

Italy participates in the European Forest Genetic Resources Programme (EUFORGEN), a collaborative programme of the European Forest Institute (EFI) to promote conservation and sustainable use of forest genetic resources, international exchange of information, joint conservation strategies, guidelines, and tools. The participation in EUFORGEN facilitates the development of science-based strategies, methods and recommendations for policymakers and managers to improve the characterization, conservation, and management of genetic resources. The program also contributes implementing the commitments of the Ministerial Conference on the Protection of Forests in Europe (MCPFE) on forest genetic resources and relevant decisions of the Convention on Biological Diversity. Within EUFORGEN, the EUFGIS-database provides geo-referenced information on forest genetic resources in Europe and data on dynamic gene conservation units (GCU). EUFGIS serves as a platform for pan-European collaboration in this area, bringing together scientists, managers, policymakers, and other stakeholders.
Recent international research activities aimed to provide the European forestry sector with better knowledge of economically and ecologically important tree species, for optimising the

management and sustainable use of FGRs in a climate change context. The above-mentioned research projects have made progress towards scientific, technological and implementation breakthroughs. Updated and refined data of *in-situ* and *ex-situ* FGR allow designing innovative strategies for dynamic conservation in European forests. New scientific knowledge on phenotypic and genotypic diversity broadens the range of FGR used in forest conservation and breeding programmes. Finally, novel outreach and science-policy support tools are fundamental to prepare new forest management scenarios and policy frameworks that fully integrate genetic conservation, breeding aspects and societal demands.

12.3 Contributions Italy provided to the international and regional cooperation on forest genetic resources

The Forestry General Direction (DIFOR) is involved in the following international activities, including aspects related to forest genetic resources:

- Participation in the Council of the European Union at the Forests Working Group, with an active contribution on the main forestry issues, including the European Green Deal.
- Participation in the Standing Forestry Committee (SFC) of the DG-AGRI of the European Commission, to assist in the preparation of legislative proposals and policy initiatives.
- Participation in the Ministerial Conference for the protection of forests in Europe, also known as "Forest Europe" (FE), with specific activities on the Forest Legally Binding Agreement (FLBA). In the last FE Ministerial Conference (Bratislava - SK, April 2021), DIFOR supported sustainable forest management and forest planning (Resolution and Declaration on European Forests).
- Contribution to the Forest Europe report on the "State of Europe's Forests", providing data from the Italian forest inventory, in collaboration with the Italian National Institute of Statistics (ISTAT).
- Participation in the United Nations Forest Forum (UNFF) in New York, which held the UNFF16 conference in April 2021 and produced the Global Forest Goals and Targets of the UN Strategic Plan for Forests 2030.

Collaboration with the UN Food and Agriculture Organization (FAO) is particularly important. DIFOR has contributed to the Global Forest Resources Assessment 2020 (FAO - FRA, 2020), with a large working group composed of national forestry experts. Furthermore, DIFOR contributes to the activities of the "International Commission on Poplars and Other Fast-Growing Trees Sustaining People and the Environment" (IPC), which will hold the 26th session in Italy in October 2021.

Italy supports the secretariat of the FAO Committee on Mediterranean Forestry Questions - *Silva Mediterranea*, with seconded staff from the Council for Agricultural Research and Economics (CREA) since September 2020.
Since 2008, Italy (CREA) has coordinated WG 4 "Forest genetic resources in the Mediterranean region" and to WG7 on Urban Forestry (UNIFI).
Italy (CREA and CNR) also participates in the IUFRO Working Party 2.02.13 "Breeding and genetic resources of Mediterranean conifers", working closely with the new IUFRO Task Force "Strengthening Mediterranean Nursery Systems for Forest Reproductive Material Procurement to Adapt to the Effects of Climate Change". The IUFRO Task Force works jointly with the *Silva Mediterranea*'s working group 4 on Forest Genetic Resources on a new regional

inventory of Mediterranean forest genetic resources to produce guidelines for the choice of plant material adapted to future climate change.
Italy is a member of the European Forest Genetic Resources Programme (EUFORGEN). The EUFORGEN Steering Committee is composed of National Coordinators from all member countries and has the overall responsibility of the programme. Italy contributes to the EUFGIS-database of EUFORGEN. At present, Italy has 210 GCUs referenced in EUFGIS. Italy also participates in the EVOLTREE (EVOLution of TREEs as drivers of terrestrial biodiversity) network of EFI, which aims to improve understanding of forest ecosystem structure, dynamics, and processes by linking genomics, genetics, ecology, and evolutionary studies. The network continuously develops initiatives, projects for long-term research, and motivates scientific discussions.

12.4 How results and/or benefits from the international and regional cooperation are applied for the conservation, use and development of forest genetic resources in Italy

The institutional system of roles and competence for the conservation, use and development of FGR in Italy is complex. The Italian Law on Forests and Forestry Chains (TUFF, D.L. n. 34/2018) is the present national framework on silviculture and forestry chains, defining the guidelines and coordination among the Regions and Ministries. The forest matter is up to different administrations: Ministry of Agriculture, Food, and Forestry Policies (MIPAAF) and the 20 Regions for the management of the territory and the production and transformation of goods; the Ministry for Ecological Transition (MITE), with responsibility for protection and conservation of the environment and biodiversity; and the Ministry for Cultural Heritage and Activities and for Tourism (MIBACT) for landscape conservation. MIPAAF carries out a coordinating function, as the primary competence on territorial and forest management remains with the Regions. The Forest Department (DIFOR) of MIPAAF has the role to coordinate the application of national laws implementing EU directives on the management and sustainable use of FGR. Because of the institutional system and the regional governance of the territory, the regulation, and laws on forests and FRM (Italian law D.L. 386/2003 in application of the EU directive 105/1999 CE) are applied in heterogeneous ways across the Italian regions. The Italian forestry sector should be implemented with a general revision of the regional situation to achieve a homogeneous application of science-based guidelines and recommendations to sustain forest genetic resources in both gene conservation units and production forests to meet the challenge of a changing environment and societal needs. It should also be necessary to merge the Italian GCUs in the EUFGIS database.

12.5 Needs, challenges, and opportunities for strengthening the international and regional cooperation on forest genetic resources

Countries in Europe have been collaborating on the conservation and sustainable use of forest tree species diversity through the European Forest Genetic Resources Programme (EUFORGEN) since 1994. During the past decade, EUFORGEN has coordinated the development of the Pan-European strategy for genetic conservation of forest trees. This strategy aims to conserve forest genetic resources at the level of the species distribution ranges through a network of dynamic genetic conservation units. As many forest species have their edge limits in neighboring countries, these countries should be implementing a similar conservation strategy to effectively conserve intraspecific tree diversity. Such conservation effort is needed both to ensure that the diversity of the species is safeguarded according to science-based guidelines and to conserve FGR of species relevant for Europe also outside its administrative boundaries. FGR management may become crucial in a changing climate, as it

is likely that Italy and southern European countries will need genetic resources more adapted to future climate scenarios and now present in neighboring countries. For this to happen, European countries should mobilise resources and cooperate with countries outside Europe to develop capacity on FGR conservation.

Chapter 13. Recommended actions for the future[14]

13.1 Availability of information on forest genetic resources

In recent years, the availability of information on to FGRs in Italy has somewhat expanded together with greater awareness of those managing them, awareness of the importance of their presence in the national territory and, above all, the adaptation potential they could offer.

This resulted from a great effort of information, training, and dissemination that some research institutions, as actors in applied research projects, have been able to carry out, involving the territorial institutions that act at different levels: national, regional, and local. First, it is necessary to recall the important action carried out within the various LIFE and Horizon 2020 programs, integrated in the past by national research programs funded by Ministry of agricultural, food and forestry policies (MIPAAF), Ministry of the ecological transition (MITE) and the Ministry of the scientific research (MIRS). These included the RiSelvItalia program, which greatly boosted the knowledge and management of FGRs and their use to produce FRM, concurrently to the implementation of the European Directive 1999/105 / EC in Italy. Clusters of regional programs aimed at applying research on the territory have been added to these national research programs.

Since 2017 with the reconstitution of the MIPAAF Directorate General for Mountain Economy and Forestry, considering what was already done by some regional offices, the national legislation has undergone an updating to align it to European legislation and promote better harmonization among the 21 competent regional offices.

In addition to establishing a technical commission for the definition of some specific aspects, the activities related to the conservation and use of the FGR mainly concerned the establishment of the national register of basic materials and the minimum criteria to classify reproductive materials as source identified or selected. Furthermore, the revision of the subdivision of the Italian territory into Provenance Regions[15] and the approval of the national list of basic materials was completed. All this was carried out at the same time as updating the regional Lists and adapting to the standards required by the European legislation (EC Regulation 1597/2002 on the format for the presentation of national lists of basic materials to produce forest reproductive).

The list of basic materials is available on the MIPAAF website (https://www.politicheagricole.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/17154) and

[14] This chapter was compiled by: Stefani A. General Director DIFOR, Ducci F. CREA FL Nervo G. CREA FL, Pompei E. DIFOR, Sabatti M. UNITUS DIBAF, Scarascia Mugnozza G. UNITUS DIBAF, Vendramin G.G. CNR IBBR.

[15] Ministry Decree on Provenance Regions: (https://eur04.safelinks.protection.outlook.com/?url=https%3A%2F%2Fwww.politicheagricole.it%2Fflex%2Fcm%2Fpages%2FServeBLOB.php%2FL%2FIT%2FIDPagina%2F17155&data=04%7C01%7Cfulvio.ducci%40crea.gov.it%7C93fcac0565b543ef820808d98f55d3ae%7Cd59c04b9bde247f7b1b80be26a568618%7C0%7C0%7C637698421061238362%7CUnknown%7CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTiI6Ik1haWwiLCJXVCI6Mn0%3D%7C1000&sdata=jdO5FR6KJjFUqePxPj213HROH%2FKB2ftuhKe3GhYmId4%3D&reserved=0)

in FOREMATIS (https://ec.europa.eu/forematis/), the Information System on forest reproductive materials, a tool made available by the European Commission to allow Member States to publish national lists of basic materials with relative geolocation.

The FOREMATIS databases and the national register of basic forest materials have been updated in collaboration with the competent regional offices, based on the provisions of the European and national legislation on the production and marketing of FRM for forestry purposes. Other data relating to FGRs can be consulted in the information systems pertaining to international networks such as EUFGIS and FAO Silva Mediterranea.

Among other things, these sources of information are helpful to identify research priorities for studying variability and adaptive traits in populations that can be a useful source of genetic information for adaptation to climate change.

The constant updating and insertion of new FBMs in the information systems spread globally, especially among stakeholders, certainly contributes to better traceability of the sources used and the possibility of exploring and evaluating their adaptive potential.

13.2 Conservation of forest genetic resources

Nowadays, *in situ* conservation of national FGRs is well ensured by the networks of Basic Materials and Protected Areas, largely overlapping and coinciding, well-considered in the National Strategy for Biodiversity, the National Forest Strategy, and the respective implementing legislation, as well as the European and national legislation for the management of FRM.

On the other hand, the large *ex situ* conservation networks, due to the lack of stable funding, cannot be maintained over time, and many sites are gradually being phased out. These *ex-situ* networks are generally created for research purposes, but the current financing methods, usually lasting a maximum of four years, prevent the subsequent exploitation of what has been achieved. Thus, an enormous scientific capital of biological materials is lost, which, in some cases, is of international as well as national interest, and which could be a source of information monitored over time relating to adaptation to changes. The loss of this capital translates or will also result in less competitiveness in participation in research programs.

13.3 Use, development, and management of forest genetic resources

Talking about FGR and their use and management makes sense especially if they are enhanced through an adequate forest nursery chain.

The forestry nursery chain to produce FRM in Italy has been at a standstill for a long time, after a period of intense activity connected with the European funding provided by the 2078 and 2080 regulations of 1992.

The legislative decree n. 386/2003, implementing Directive 1999/105 / EC, attributing a large part of the competence to the 21 official regional bodies, resulted in a heterogeneous situation at the national level. In some Regions where the forestry sector has valuable economic importance, the use of FRM has also been the subject of specific regulations aimed at promoting their appropriate use, ensuring their traceability, and promoting the conservation of the original materials.

The legislative decree n. 34/2018, Consolidated law on forests and forestry chains (TUFF), has tried to establish unitary coordination by attributing it to the Technical Commission, already

provided for by legislative decree no. 386/2003, to stimulate the effective resumption of activities relating to this increasingly strategic sector.

The National Strategy for Biodiversity and the National Forest Strategy, in line with the European forestry strategy and measures envisaged by the National Recovery and Resilience Plan (PNRR), have contributed significantly to a general renewed interest in FGRs.

The research bodies dealing with FGR study and conservation in Italy certainly have the scientific basis and the communicative capacity to favor the dissemination of the concept, according to which the success of the interventions mainly depends on the correct use of these resources.

The regulatory basis of the supply chain, derived from the European legislation and constituted by the legislative decree n. 386/2003, was supplemented by the decrees for the establishment and approval of the national register of basic materials and the revision of the Provenance Regions, proposed by the Technical Commission which operates at the MIPAAF's General Directorate for Mountain Economy and Forestry.

The legislative decree n. 34/2018, whose implementation decree is being drafted, also established new National Centers for Forest Biodiversity, of fundamental importance for all aspects relating to FGRs.

13.4 Policies, institutions, and capacity-building

A greater synergy must be fostered between research institutions dealing with FGRs and relevant ministries (MIPAAF, MITE, and MIUR) and Regions.
There is a consensus that the identification, conservation and use of FGRs require the involvement and intervention of many stakeholders, public and private, and that each one gives its own contribution to favor the development of this sector. That is of strategic importance not only for the Italian forests but also for the future of the forests of central and northern Europe. Indeed, it is not possible to ignore the increasingly frequent requests of FRM for research on the adaptation of southern populations at higher latitudes and on assisted migration. In addition to the nursery production, it is also necessary to stimulate and finance research programs aimed at supporting and identifying and characterizing new FGRs.

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ANNEX 1 – TABLES

Table 2.1. Forest characteristics and areas in Italy (FAO – FRA, 2020)

Main forest characteristics	**Area (ha)**
Forests	9 566 130
Other wooded land	1 865 840
Other land	17 982 030
Total land area	**29 414 000**
Primary forest	93 000
Naturally regenerated forests	8 921 090
Planted forest	644 990

Table 2.2. Analytical carbon stock distribution in the national forests between 1990 and 2020 (Source FAO - FRA, 2020)

Carbon stock

See definitions FAQ

CSV

FRA categories	Forest carbon (tonnes/ha)								
	1990	2000	2010	2015	2016	2017	2018	2019	2020
Carbon in above-ground biomass	42.30	47.60	52.70	55.30	55.30	55.30	55.30	55.30	55.30
Carbon in below-ground biomass	10.40	11.70	13.00	13.70	13.70	13.70	13.70	13.70	13.70
Carbon in dead wood	2.40	2.70	3.00	3.10	3.10	3.10	3.10	3.10	3.10
Carbon in litter	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20
Soil carbon	81.70	81.70	81.70	81.70	81.70	81.70	81.70	81.70	81.70

Soil depth (cm) used for soil carbon estimates	30.00

Table 3.1. Surface covered OWLs in Italy reported by the National Forest inventory. On the right side as "*altre terre boscate*" (Gasparini and Tabacchi, INFC, 2005) on the left side "Bosco" means "Forests".

Distretto territoriale	Bosco								Altre terre boscate							
	Presenza di microhabitat		Assenza di microhabitat		Superficie non classificata per presenza di microhabitat		Totale Bosco		Presenza di microhabitat		Assenza di microhabitat		Superficie non classificata per presenza di microhabitat		Totale Altre terre boscate	
	superficie (ha)	ES (%)	superficie (ha)	ES (%)	superficie (ha)	ES (%)	superficie (ha)	ES (%)	superficie (ha)	ES (%)	superficie (ha)	ES (%)	superficie (ha)	ES (%)	superficie (ha)	ES (%)
Piemonte	501 076	2.1	368 710	2.7	808	70.8	870 594	1.1	24 299	12.8	23 178	13.2	22 045	13.1	69 522	7.2
Valle d'Aosta	51 608	6.7	46 831	7.2	0	-	98 439	3.1	1 927	44.3	1 883	41.9	3 680	31.2	7 489	21.4
Lombardia	251 182	3.5	354 864	2.7	0	-	606 045	1.4	16 561	16.1	26 700	12.6	16 396	16.1	59 657	8.2
Alto Adige	192 120	3.3	143 813	4.2	756	70.5	336 689	1.6	14 761	15.9	16 264	14.9	4 460	28.2	35 485	9.9
Trentino	195 617	3.3	179 784	3.5	0	-	375 402	1.4	14 581	15.7	13 585	16.2	3 963	29.2	32 129	10.3
Veneto	229 101	3.1	168 788	4.0	0	-	397 889	1.7	8 929	20.3	18 449	14.1	21 589	12.8	48 967	8.3
Friuli V.G.	149 048	4.0	174 784	3.5	0	-	323 832	1.7	8 088	21.1	14 405	15.7	10 899	17.7	33 392	9.9
Liguria	123 290	4.6	215 450	2.9	366	99.3	339 107	1.5	12 774	16.5	8 678	20.1	14 575	15.3	36 027	9.5
Emilia Romagna	290 127	2.8	273 135	3.0	0	-	563 263	1.4	11 402	17.8	12 847	16.8	21 307	12.3	45 555	8.5
Toscana	311 460	3.0	703 907	1.6	361	100.0	1 015 728	1.0	21 695	12.8	43 384	9.0	70 732	6.9	135 811	4.9
Umbria	86 867	5.9	284 708	2.2	0	-	371 574	1.4	8 455	20.1	5 432	25.7	4 795	27.1	18 681	13.4
Marche	75 436	6.3	215 958	2.8	0	-	291 394	1.8	2 572	37.7	4 445	28.8	9 665	16.0	16 682	12.8
Lazio	149 506	4.5	394 378	2.1	0	-	543 884	1.4	15 056	15.5	33 340	10.3	13 579	15.7	61 974	7.3
Abruzzo	157 283	4.0	233 846	2.9	362	100.1	391 492	1.5	16 641	14.2	16 599	14.6	13 859	13.1	47 099	7.6
Molise	40 704	8.6	91 859	4.6	0	-	132 562	2.9	6 337	24.0	6 878	23.2	2 864	29.5	16 079	14.2
Campania	119 700	5.0	264 695	2.8	0	-	384 395	1.9	12 889	16.7	27 980	11.2	20 010	12.5	60 879	7.3
Puglia	64 359	6.7	81 182	5.7	349	99.8	145 889	3.4	13 576	16.3	15 169	15.4	4 406	27.6	33 151	10.0
Basilicata	57 778	7.5	205 320	3.1	0	-	263 098	2.4	17 131	14.5	55 878	7.6	20 320	13.2	93 329	5.6
Calabria	176 084	4.0	290 575	2.8	1 493	49.9	468 151	1.8	15 671	15.3	45 709	8.7	83 401	6.3	144 781	4.6
Sicilia	123 815	4.8	132 488	4.6	0	-	256 303	2.7	32 215	10.4	42 242	9.1	7 411	21.3	81 868	6.2
Sardegna	202 518	4.0	379 089	2.7	1 866	44.7	583 472	2.0	206 715	3.9	394 922	2.6	28 141	11.2	629 778	1.8
Italia	3 548 678	0.9	5 204 162	0.6	6 361	24.2	8 759 200	0.4	482 275	2.7	827 964	2.0	398 095	2.9	1 708 333	1.3

Table 4.1. Species for which variation, monitoring, and conservation programmes are being conducted in Italy.

Species	**National distribution available**	**Non-molecular characterization**	**Molecular characterization**	***In situ* programme**	**No. of *in situ* units**	**Area of *in situ* (ha)**	***Ex situ* programme**	**No. of *ex situ* units**	**Area of *ex situ* (ha)**	**No. of *ex situ* accessions**	**National tree seed programmes**	**Tree breeding programmes**	**Area of seed stands (ha)**	**No. of seed stands**	**Area of seed orchards (ha)**	**No. of seed orchards**	**Amount of planting stock produced per year**	**State of tree breeding programme (generation)**
Abies alba	1	1	1	1	53	18243.7	1	8	6	26	1	1	18243.7	53	0	0	0	1
Abies cephalonica	1	0	0	0	0	0	1	5	7	11	1	1	4	1	0	0	0	1
Abies nebrodensis	1	1	1	1	1	150	1	2	2	29	1	1	150	1	0.80	1		1
Abies nordmanniana	0	1	0	0	0	0	1	1	1	3	0	0	0	0	0	0	100000	1
Acer campestre	1	1	0	1	69	23581.4	1	4	6	7	1	1	23581.4	69	0	0	20000	1

Acer cappadocicum	1	0	0	1	1	30	0				1	0	30			0		n.a.
Acer opalus	1	0	0	1	15	17212	0				1	0	17212	15		0	10000	n.a.
Acer platanoides	1	0	0	1	13	9257.3	0				1	0	9257.3	13		0	20000	n.a.
Acer pseudoplatanus	1	0	0	1	61	26195	0				1	0	26195	61		0	50000	n.a.
Alnus cordata	1	1	0	1	7	487.2	0	3	12	5	1	1	487.2	7	0	1	100000	2
Alnus glutinosa	1	0	0	1	48	14723	0				1	0	14723	48		0		n.a.
Alnus incana	1	0	0	1	17	1478.6	0				1	0	1478.6	17		0		n.a.
Betula pendula	1	0	1	1	28	21361.4	0				1	0	21361.4	28		0	20000	n.a.
Betula pubescens	1	0	0	0	3	165.5	0				1	0	165.5	3		0		n.a.
Carpinus betulus	1	0	0	1	71	25266	0				1	0	25266	71		0	50000	n.a.
Castanea sativa	1	1	1	1	67	201967	1	3	8	353	1	1	20196.9	67	9.90	5	15000	3
Cedrus atlantica	0	1	0	0	0	0	1	5	6.8	189	1	1	255	2	0	0	20000	2
Cedrus deodara	1	1	0	0		0	1	4	262.3		1	0	262.3	4		0	10000	1
Cedrus libani	0	1	0	0	0	0	1	9	4.32	12	1	1	0	0	0	0	10000	2
Celtis australis	1	0	0	1	1	27	0				1	0	27	1		0	10000	1
Cupressus sempervirens	1	1	1	1	22	4388.5	1	3	24	8128	1	1	4388.5	22	0.80	1	50000	2
Eucalyptus globulus	1	1	0	0	0	0	1	1	2	340	1	1	63	1	0	0	20000	2
Fagus sylvatica	1	1	1	1	94	37580	1				1	0	37580	94		0	200000	1
Fraxinus angustifolia	1	0	0	1	20	2245.4	1				1	0	2245.4	20	0	0	10000	n.a.
Fraxinus excelsior	1	0	1	1	70	21224.2	0	0	0	0	1	0	21224.2	70	0	0	150000	1
Fraxinus ornus	1	0	0	1	51	17809.5	0				1	0	17809.5	51		0	50000	n.a.
Juglans nigra	1	0	0	0	0	115.10	1	4	6	54	1	1	115.10	4	0	0	10000	1.5

Juglans nigra x regia	0	1	1	1	1	3	1	1	1.5	36	1	1	3	1	1	2	10000	2
Juglans regia	1	1	1	1	19	810.7	1	11	6	195	1	1	810.7	19	1.85	4	20000	2
Larix decidua	1	1	1	1	31	4224.3	1	2	4	37	1	1	4224.3	31	0	0	150000	1
Ostrya carpinifolia	1	0	0	1	48	26366.5	0				1	0	26366.5	48	0	0		n.a.
Picea abies	1	1	1	1	40	14287.7	1	2	2.5	16	1	1	14287.7	40	3	2	150000	2
Pinus brutia	1	1	1	1	1	6	1	3	3	29	1	1	6	1	2.60	2	5000	1.5
Pinus cembra	1	0	1	1	29	3656	0				1	0	3656	29	0	0	20000	1
Pinus halepensis	1	1	1	1	40	7482.5	1	12	10	50	1	1	7482.5	40	0	0	20000	1.5
Pinus heldreichii	1	0	1	1	1	150	0	0	0	0	1	0	150	0	0	0	2000	1
Pinus mugo	1	0	0	1	10	1876	0	0	0	0	1	0	1876	10	0	0	10000	n.a.
Pinus nigra	1	1	1	1	33	6934.7	0	0	0	0	1	1	6934.7	33	0	0	100000	1
Pinus pinaster	1	1	1	1	14	3427.5	1	16	28.44	421	1	1	3427.5	14	0	0	10000	1.5
Pinus pinea	1	1	1	1	23	11257	1	0	0	0	1	1	11257	23	0	0	50000	1
Pinus sylvestris	1	1	1	1	30	8859.6	1	1	4	12	1	1	8859.6	30	0.70	1		
Populus × canadensis	1	1	1	1			1	29	10	182	1	1				0	150000	4
Populus alba	1	1	1	1			1	5	2	537	1	1	0	0	0	0	5000	1.5
Populus deltoides	1	0	0	0			1	12	6	179	1	1				0		3
Populus nigra	1	1	1	1	38	10499.6	1	10	12.9	568	1	1	10499.6	38	50	3	300000	4
Prunus avium	1	1	1	1	88	808	1	14	14	402	1	1	808	3	5.6	3	90000	2
Prunus serotina	1	0	0	0			1	1	4	10	0	0				0		n.a.
Pseudotsuga menziesii	1	1	1	1	2		1	9	259	168	1	1	259	2	2.5	3	50000	2
Quercus cerris	1	0	0	1	114	25565	1	3	6	12	1	0	25565	114	0	0	200000	1.5
Quercus frainetto	1	0	0	1	0	0	0				1	0				0		n.a.

Quercus ilex	1	0	1	1	103	30975.6	1	1	2	2	1	0	30975.6	103	0	0	150000	1
Quercus petraea	1	1	1	1	46	10055.7	0	0	0	0	1	0	10055.7	46	0	0	50000	1.5
Quercus pubescens	1	0	1	1	85	21590.3	0	0	0	0	1	0	21590.3	85	0	0	80000	1.5
Quercus robur	1	1	1	1	103	17960.5	1	2	45	15	1	1	17960.5	103	0	0	50000	1.5
Quercus suber	1	1	1	1	37	5948.5	1	5	4	54	1	1	5948.5	39	0	0	50000	1.5
Quercus trojana	1	0	0	1	1	733	0				1	0	733	1		0		n.a.
Robinia pseudoacacia	1	1	0	0	8	1762,9	1	4	8	150	1	1	0	0	0	0	2	n.a.
Salix alba	1	1	0	1	23	8481.8	1	2	3.5	590	1	1	8481.8	23	0	0	300000	1.5
Sorbus torminalis	1	0	0	1	2	184	1	3	2	183	1	1	184	2	0.5	1	10000	1
Taxus baccata	1	0	1	1	10	14043.7	0				1	0	14043.7	10		0	30000	n.a.
Tilia cordata	1	0	0	1	34	7879.4	0				1	0	7879.4	34		0	10000	n.a.
Tilia platyphyllos	1	0	0	1	1	232	0				1	0	232	1		0		n.a.
Ulmus glabra	1	1	1	1	1	51.53	1	2	1	13	1	1	51.53	1	0.5	1		4
Ulmus laevis	0	1	1	1	1	110	1	1	0.5	4	1	1	110	1	0.5	1		2
Ulmus minor	1	1	1	1	51	8235.9	1	1	3	105	1	1	8235.9	51	0.5	1	50000	4
Ulmus pumila	0	0	0	0			1	1	0.5	3	0	0				0		n.a.

Table 4.2. Threatened species in Italy and main characteritics.

Species	*Area (ha) of species natural distribution	Average Number of trees per hectare	**Proportion of species' natural distribution (%)	Distribution in the country: widespread (W), rare (R), or local (L)	Type of threat (Code)	Threat category***		
						high	Medium	low
Abies nebrodensis	150	0.5	100	L	1, 15	x		
Abies alba (Some southern marginal populations)	65 000	--	--	W	1, 11, 15		x	
Betula pendula	20 000	10	100	R	15	x		
Betula aetnensis	425	50	100	L	15	x		
Pinus leucodermis	2 610	--	--	L	1, 15		x	
Taxus baccata	1 100 000	0.25	--	W	1, 5, 15		x	
Ulmus glabra	--	--	--	W	11, 13	x		
Ulmus minor	--	--	--	W	11, 13	x		
Zelkova sicula	3	82	100	L	2, 8, 13	x		

Table 6.1. Number of *in situ* conservation units for each of the species in Italy.

Tree species	*In situ* conservation units (N)
Abies alba	53
Abies nebrodensis	1
Acer campestre	69

Acer cappadocicum var. lobelii	1
Acer opalus subsp. obtusatum	4
Acer opalus	15
Acer platanoides	13
Acer pseudoplatanus	61
Alnus cordata	7
Alnus glutinosa	48
Alnus incana	17
Betula aetnensis	1
Betula pendula	28
Betula pubescens	3
Carpinus betulus	71
Castanea sativa	67
Celtis australis	1
Cupressus sempervirens	22
Fagus sylvatica	94
Fraxinus angustifolia	20
Fraxinus excelsior	70
Fraxinus ornus	51
Juglans regia	19
Larix decidua	31
Ostrya carpinifolia	48
Picea abies	40
Pinus brutia	1
Pinus cembra	29
Pinus halepensis	40
Pinus heldreichii	1
Pinus mugo	10
Pinus nigra var. laricio	19
Pinus nigra var. austriaca	14
Pinus pinaster	14
Pinus pinea	23
Pinus sylvestris	30
Populus nigra	38
Populus tremula	11
Prunus avium	88
Quercus cerris	114
Quercus ilex	103
Quercus petraea	46
Quercus pubescens	85
Quercus robur	103
Quercus suber	37
Quercus trojana	1
Salix alba	23
Sorbus torminalis	2
Taxus baccata	10

Tilia cordata	34
Tilia platyphyllos	1
Ulmus glabra	1
Ulmus laevis	6
Ulmus minor	51

Table 6.2. Number of seed stands for each species and areas for each category. Category 1 means “source identified”: category 2 means “selected seed stands”.

Tree species	**Category**	**Seed Stands (N)**	**Area (ha)**
Abies alba	1	24	8946.60
Abies alba	2	29	9297.10
Abies nebrodensis	1	1	150.00
Acer campestre	1	68	23558.40
Acer campestre	2	1	23.00
Acer opalus subsp. obtusatum	1	4	4813.80
Acer opalus	1	11	12398.90
Acer platanoides	1	11	8805.80
Acer platanoides	2	2	451.53
Acer pseudoplatanus	1	58	25511.40
Acer pseudoplatanus	2	3	683.53
Alnus cordata	1	2	87.20
Alnus cordata	2	5	400.00
Alnus glutinosa	1	48	14723.00
Alnus incana	1	17	1478.56
Betula aetnensis	1	1	483.00
Betula pendula	1	28	21361.40
Betula pubescens	1	3	165.54
Carpinus betulus	1	69	24518.70
Carpinus betulus	2	2	747.00
Castanea sativa	1	65	19951.90
Castanea sativa	2	2	245.00
Celtis australis	1	1	27.00
Cupressus sempervirens	1	18	4236.46
Cupressus sempervirens	2	3	152.00
Fagus sylvatica	1	85	35399.60
Fagus sylvatica	2	9	2179.90
Fraxinus angustifolia	1	19	1955.70
Fraxinus angustifolia	2	1	289.70
Fraxinus excelsior	1	66	20729.72
Fraxinus excelsior	2	4	494.50
Fraxinus ornus	1	51	17809.50
Juglans regia	1	19	810.7

Larix decidua	1	18	2965.30
Larix decidua	2	13	1259.00
Ostrya carpinifolia	1	48	26366.50
Picea abies	1	28	13175.70
Picea abies	2	12	1112.00
Pinus brutia		1	6.0
Pinus cembra	1	21	2195.00
Pinus cembra	2	8	1461.00
Pinus halepensis	1	24	4799.50
Pinus halepensis	2	16	2683.00
Pinus mugo	1	8	1383.10
Pinus mugo	2	2	493.00
Pinus nigra var. austriaca	1	7	1170.70
Pinus nigra var. austriaca	2	7	1191.00
Pinus nigra var. laricio	1	4	398.00
Pinus nigra var. laricio	2	15	4135.00
Pinus nigra var. villetta Barrea	2	1	40.00
Pinus pinaster	1	9	2574.50
Pinus pinaster	2	5	853.00
Pinus pinea	1	18	7553.10
Pinus pinea	2	5	3704.00
Pinus sylvestris	1	21	8005.60
Pinus sylvestris	2	9	854.00
Populus nigra	1	38	10499.60
Populus tremula	1	11	5572.90
Prunus avium	2	3	808.00
Quercus cerris	1	99	24295.60
Quercus cerris	2	15	1269.40
Quercus ilex	1	99	30881.10
Quercus ilex	2	4	94.50
Quercus petraea	1	41	9092.70
Quercus petraea	2	5	963.00
Quercus pubescens	1	84	21579.30
Quercus pubescens	2	1	20.00
Quercus robur	1	97	16674.10
Quercus robur	2	6	1286.40
Quercus suber	1	37	5942.60
Quercus suber	2	2	5.90
Quercus trojana	1	1	733.0
Salix alba	1	23	8481.80
Sorbus torminalis	2	2	184.00
Taxus baccata	1	10	14043.70
Tilia cordata	1	31	7779.90
Tilia cordata	2	3	99.53

Tilia platyphyllos	2	1	232.00
Ulmus glabra	2	1	51.53
Ulmus laevis	2	1	110.00
Ulmus minor	1	51	8235.90

Table 6.3. List of natural reserves (RN) and natural biogenetic reserves (RNB) for each target species.

	RN + RNB	**Area (ha)**
Abies alba	24	11646.00
Abies nebrodensis	1	150.00
Abies campestre	5	389.50
Acer monspessulanum	1	15.00
Acer pseudoplatanus	5	225.00
Alnus cordata	2	150.00
Alnus glutinosa	4	49.00
Betula pendula	4	41.21
Carpinus betulus	7	105.00
Castanea sativa	12	592.80
Cupressus sempervirens	2	2.00
Fagus sylvatica	43	27874.20
Fraxinus angustifolia	3	312.00
Fraxinus excelsior	6	102.00
Fraxinus ornus	7	2983.00
Juglans regia	2	68.90
Larix decidua	6	4350.00
Malus sylvestris	3	3.00
Ostrya carpinifolia	9	7738.00
Picea abies	8	16091.00
Pinus brutia	2	3.30
Pinus halepensis	6	1927.50
Pinus heldreichii/leucodermis	3	2305.00
Pinus mugo	4	4271.00
Pinus nigra	3	2600.00
Pinus nigra v. laricio	13	10949.00
Pinus nigra v. austriaca	1	21.00
Pinus pinaster	5	1384.00
Pinus pinea	10	2109.50
Pinus sylvestris	2	1410.00
Populus alba	1	30.00
Populus nigra	2	21.00
Populus tremula	4	40.50
Quercus cerris	16	3132.00
Quercus frainetto	4	973.00

Quercus ilex	15	3285.00
Quercus petraea	1	6.00
Quercus pubescens	16	5034.47
Quercus robur	7	3309.00
Quercus rubra	1	3.50
Quercus suber	3	15.50
Quercus trojana	2	1230.00
Quercus virgiliana	2	748.00
Salix alba	2	14.00
Sorbus aucuparia	4	27.00
Sorbus domestica	1	15.00
Taxus baccata	5	1778.00
Tilia cordata	1	5.00
Ulmus minor	3	36.00
Ulmus pumila	1	5.00

Table 6.4. Regional legislation and regulations relevant with FGR management.

Regional Authority	**Legislative reference**	**Forestry Regulations and/or PMPF**	**Implemented EU Dir. 1999/105/CE or Lgs Decr. 386/03**	**Notes relevant to FGR management**
Valle d'Aosta	L.R. 4/1958	General and forestry police prescriptions (PMPF) R.D.L.3267/1923	no	nothing
Piemonte	L.R. 4/2009	Forestry Regulation. 8/R/2011 et al.	yes	Art. 5 (forest nursery) Art. 13 (Forest regulation) Sez. III (protection of the genetic heritage of native tree and shrub species and forest nursery production). Annex D of the Regulation (List of sporadic species). FBM Regional Register established
Liguria	L.R. 4/1999	Regional Regulation 1/1999	no	Art. 4 (Typology of interventions), art. 13 (Regional Forest nurseries)
Lombardia	L.R. 31/2008	Regional Regulation 5/2007	yes	Art. 53 (FBM and FRM). Art. 27 (Collection of FRM and Seed stands) and 51 (Plant material) of the Regional Regulation. FBMs Regional Register established
Prov. Autonoma di Trento	L.P. 11/2007	Regulations D.P. 51-158/2008	yes	Chapter III of the Province Law FBM Regional Register established
Prov. Autonoma di Bolzano	L.P. 21/1996	Province's President Decree n. 29/2000	yes	Chapter VI (FRM) of the Province Law FBM Regional Register established
Veneto	L.R. 52/1978 integrated	General and forestry police	yes	Art. 28 of the L.R. FBM Regional Register established

	with L.R. 5/2005	prescriptions (PMPF) 51/2003 DGR 3263 of 15/10/2004		
Friuli-Venezia-Giulia	L.R. 9/2007	Forestry Regulation 274/2012	yes	Section IV (Forest nursery and FRM). No FBM Regional Register has been established, although there is a list of seed stands
Emilia-Romagna	L.R. 30/1981 e ss.mm.ii. L.R. 10/2007 (implementing Lgs Decree 386/03)	general and forestry police prescriptions D.G.R. 182/1995	yes	FBM Regional Register established
Toscana	L.R. 29/2000	Regional Regulation 48/2003	yes	CAP III (FRM) Art. 12 Regulation (Protection of biodiversity). FBM Regional List established
Marche	L.R. 6/2005	General and forestry police prescriptions (PMPF) D.G.R. 2585/2001	yes	Art. 14 (Regional List of Seed Stands), art. 17 (public forest nurseries) e 20 (Protecting high forest tree) L.P. 21/1996.
Umbria	L.R. 28/2001	Regional Regulation 11/2012	yes	Title V of L.R. Title X of Regulation Regional List of FBMs established
Abruzzo	L.R. 3/2014	L. 3/2014 and province's general and forestry police prescriptions (PMPF) 43/1965.	yes	Capo IV art. from 57 to 62. Management plans of seed stands are included in the registration sheets. Regional List of FBMs established
Molise	DGR 528/2007 and DGR 836/2010		yes	FRM certification pursuant to Legislative Decree 386/2003 (DGR 528/2007) "Implementation of Directive 1999/105 / EC concerning the marketing of forest multiplication materials"; - establishment of the Regional List of FBM (seed stands) (DGR 836/2010) and registration in the official list.
Lazio	L.R. 39/2002 L.R. 3/2010	Regional Regulation 7/2005	yes	Art. 49 of the regulation (stands addressed to biodiversity and germplasm protection)
Campania	L.R. 11/1996	General and forestry police prescriptions (PMPF) annex C to L.R.	yes	Artt. 2, 5, 7, 8 e 9
Puglia	L.R. 18/2000	Regional Regulation 10/2009	yes	Art. 4 (Aims)
Basilicata	L.R. 42/1998. D.G.R. n.247 of 26th February 2008 implementing L.Dec. 386/03	DGR n. 956/2004	yes	Art. 2 L.R (actions)
Calabria	L.R. 45/2012	General and forestry police prescriptions	yes	Artt. 2, 16 e 17 relevant to forest nurseries

		(PMPF) D.G.R. 218/2011		
Sicilia	L.R. 271/2016	Province's general and forestry police prescriptions (PMPF)		
Sardegna	L.R. 8/2016	PMPF n,24/CFVA/2006	yes	Art. 2 of the L.R. (aims) e art. 23 (forest nursery)

Table 6.5. Main players and stakeholders actively engaged *in situ* conservation.

Name of institution	**Type of institution**	**Contact information**
Ministry of Agriculture, Food and Forest Policies MIPAAF	Government	Direzione Generale delle Foreste MIPAAF Via XX Settembre, 20 – 00185 Roma, Italia https://www.politicheagricole.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/12237 FRM-Italy@politicheagricole.it segreteria.direzioneforeste@politicheagricole.it
Ministry of the Environment	Government	Direzione Generale per il Patrimonio Naturalistico (PNA) Via Cristoforo Colombo, n. 44 00147 - Roma (Italia) https://www.minambiente.it/pagina/direzione-generale-il-patrimonio-naturalistico-pna PNA-UDG@minambiente.it
Ministry of Defense	Government	Biodiversity Office (ex- National Forest Service) Via Carducci, 5 – 00185 Roma, Italia http://www.carabinieri.it/arma/oggi/organizzazione/organizzazione-per-la-tutela-forestale-ambientale-e-agroalimentare/utcb-e-le-130-riserve-naturali
Council for Agricultural Research and Economics CREA	Research public body	Research Centre for Forestry and Wood CREA https://www.crea.gov.it/en/web/foreste-e-legno fl@crea.gov.it Viale S. Margherita, 80 – 52100 Arezzo, Italia
Consiglio Nazionale delle Ricerche CNR	Research public body	Institute for sustainable plant protection CNR IPSP http://www.ipsp.cnr.it/ direttore@ipsp.cnr.it Sede Secondaria Sesto fiorentino, Via Madonna del Piano 10 - 50019 Sesto Fiorentino (FI), Italia
Università di Firenze	Research public body	Dipartimento di Scienze e Tecnologie Agrarie, Alimentari, Ambientali e Forestali DAGRI - sezione Foreste ambiente legno paesaggio FALP www.dagri.unifi.it dagri@pec.unifi.it Via San Bonaventura, 13 50145 FIRENZE, Italy
Università di Padova	Research public body	Department of Land, Environment, Agriculture and Forestry TESAF viale dell'Università 16, 35020 Legnaro (PD) https://www.unipd.it/en/tesaf direzione.tesaf@unipd.it
Università degli Studi della Tuscia	Research public body	Department for innovation in biological, agro-food and forest systems DIBAF https://www.unitus.it/it/dipartimento/dibaf dibaf@unitus.it Via San Camillo de Lellis s.n.c.01100
Università degli Studi di Torino	Research public body	Dipartimento di Scienze Agrarie, Forestali e Alimentari DISAFA https://www.disafa.unito.it/do/home.pl direzione.disafa@unito.it Largo Paolo Braccini, 2 (già Via Leonardo da Vinci, 44) 10095 GRUGLIASCO (TO)

Università di Parma	Research public body	Prof. Stefano Leonardi ecogenetica
Regione Abruzzo	Government	http://www2.consiglio.regione.abruzzo.it/leggi_tv/storico/2014/lr14003.htm Servizio Presidi Tecnici di Supporto al Settore Agricolo – DPD023 - Ufficio Direttiva Nitrati, Qualità dei Suoli, Coordinamento Servizi Vivaistici ed Agrimeteo (Cepagatti-Scerni) DPD023/002.
Provincia Autonoma di Bolzano	Government	http://www.provincia.bz.it/agricoltura-foreste/bosco-legno-malghe/vivai-forestali/regolamento-legislativo.asp Ripartizione 32 – Foreste. Via Brennero 6 - 39100 Bolzano Tel: 0039-0471415300 - FAX: 0039-0471415313. forest@provinz.bz.it; forstwirtschaft.foreste@pec.prov.bz.it
Regione Calabria	Government	Dipartimento Presidenza. U.O.A. Politiche della Montagna, Foreste, Forestazione e Difesa del Suolo. PEC: forestazione.presidenza@pec.regione.calabria.it
Regione Campania	Government	http://agricoltura.regione.campania.it/foreste/boschi_da_seme.html Direzione Generale per le Politiche Agricole Alimentari e Forestali - Unità Operativa Dirigenziale "Ufficio Centrale Foreste e Caccia dg.500700@pec.regione.campania.it; uod.500704@pec.regione.campania.it
Regione Emilia-Romagna	Government	https://ambiente.regione.emilia-romagna.it/it/parchi-natura2000/foreste/gestione-forestale/boschi-da-seme-e-vivai/boschi-da-seme-e-vivai-forestali Servizio Aree Protette, Foreste e Sviluppo della Montagna - Viale della Fiera 8, 40127 Bologna. segrprn@postacert.regione.emilia-romagna.it; per gli aspetti fitosanitari e produttivi (punti 5 e 6) Servizio Fitosanitario - Via A. da Formigine 3 - 40128 Bologna. omp1@postacert.regione.emilia-romagna.it.
Regione Friuli-Venezia Giulia	Government	http://www.regione.fvg.it/rafvg/cms/RAFVG/economia-imprese/agricoltura-foreste/foreste/FOGLIA10/ Establishment and updating of the register of FBM of species occurring in the regional territory: Direzione centrale risorse agroalimentari, forestali e ittiche - Servizio foreste e corpo forestale - indirizzo: UDINE - Via Sabbadini, 31 telefono: 0432555111 – corpoforestale@regione.fvg.it; PEC: corpoforestale@certregione.fvg.it. Controls on the production and certification of FRM: ERSA - agenzia regionale per lo sviluppo rurale - Servizio fitosanitario e chimico, ricerca, sperimentazione e assistenza tecnica; indirizzo: POZZUOLO DEL FRIULI - Via Sabbatini, 5 - telefono: 0432529266. ersa@ersa.fvg.it; PEC: ersa@certregione.fvg.it.
Regione Lombardia	Government	https://www.regione.lombardia.it/wps/portal/istituzionale/HP/DettaglioRedazionale/servizi-e-informazioni/Imprese/Imprese-agricole/Boschi-e-foreste/normativa-boschi-e-foreste/registro-boschi-da-seme/registro-boschi-da-seme Direzione Generale: Agricoltura, Alimentazione e Sistemi verdi - Struttura: Sviluppo delle politiche forestali e della montagna PEC: agricoltura@pec.regione.lombardia.it
Regione Marche	Government	Servizio Politiche Agroalimentari - Posizione di Funzione Interventi nel settore forestale e dell'irrigazione e SDA di Ancona - Via Tiziano 44 - 60100 Ancona. PEC regione.marche.pfcsi@emarche.it
Regione Molise	Government	Dipartimento II - Risorse finanziarie Valorizzazione ambiente e risorse naturali Sistema regionale autonomie locali. Servizio Fitosanitario Regionale Tutela e valorizzazione della montagna e delle foreste, biodiversità e sviluppo sostenibile. Ufficio Natura 2000 and VincA Network Management, Monumental Trees, FGR Conservation and FRM Control.
Regione Piemonte	Government	https://www.regione.piemonte.it/web/temi/ambiente-territorio/foreste/servizio-informativo-forestale-regionale-sifor

		Direzione Ambiente, Energia e Territorio - Settore Foreste - foreste@cert.regione.piemonte.it - two structures operate within the Regional Directorate for Forestry Nursery: a) Forestry Sector (Turin), for legislative and regulatory aspects, the Register of FBMs, production and marketing licenses; b) Technical Sector of Biella and Vercelli (Vercelli), for the coordination of forest nurseries owned by the Region.
Regione Puglia	Government	http://foreste.regione.puglia.it/vivaiforeste Servizio Risorse Forestali, della Sezione Gestione Sostenibile e Tutela delle Risorse Forestali e Naturali, Dipartimento Agricoltura e Sviluppo Rurale e Ambientale - PEC: protocollo.sezionerisorsesostenibili@pec.rupar.puglia.it.
Regione Autonoma della Sardegna	Government	http://www.sardegnaambiente.it/documenti/19_173_20141106111950.pdf a) Assessorato della difesa dell'ambiente - Servizio tutela della natura e politiche forestali (general coordination and enforcement of provisions - PEC difesa.ambiente@pec.regione.sardegna.it); b) Corpo forestale e di vigilanza ambientale - Direzione Generale - Supervision and technical coordination service (PEC cfva. vigilanza@pec.regione.sardegna.it); c) Assessorato dell'agricoltura e riforma agro-pastorale - Direzione generale dell'agricoltura e riforma agro-pastorale - Servizio sostenibilità e qualità delle produzioni agricole e alimentari (PEC agricoltura@pec.regione.sardegna.it)
Regione Siciliana	Government	http://pti.regione.sicilia.it/portal/page/portal/PIR_PORTALE/PIR_LaStrutturaRegionale/PIR_Assessoratoregionaledelterritorioedellambiente/PIR_Comandocorpoforestale/PIR_Areetematiche/PIR_Altricontenuti/PIR_Controllovivaismo Comando Corpo Forestale Regione Sicilia - Servizio 5 Interventi Opere pubbliche tutela ed economia montana - Unità operativa 14 Vincolo Idrogeologico PEC: comando.corpo.forestale@certmail.regione.sicilia.it
Regione Toscana	Government	Direzione Agricoltura e Sviluppo Rurale Settore Forestazione. Usi Civici. Agroambiente Via di Novoli 26 - 50127 FIRENZEPEC: regionetoscana@postacert.toscana.it
Provincia Autonoma di Trento	Government	Servizio Foreste e fauna - via G.B. Trener, 3 - 38121 TRENTO - serv.foreste@pec.provincia.tn.it
Regione Umbria	Government	Giunta Regionale. Forestry, Mountain, Naturalistic Systems Service Forest Protection and decentralized functions Section direzioneagricoltura.regione@postacert.umbria.it
Regione Valle d'Aosta	Government	Assessorato Ambiente, Natural Resources and Forestry Corps - Natural Resources Department - Flora, fauna, hunting and fishing - Public green office, nurseries, monumental plants and gardens. Loc. Amerique 127/A 11020 Quart (0165/776247) - risorse_naturali@pec.regione.vda.it
Regione Veneto	Government	https://www.regione.veneto.it/web/economia-e-sviluppo-montano/materiale-di-propagazione-forestale Direzione Enti Locali e Servizi Elettorali - Unità Organizzativa Politiche per lo Sviluppo Turistico della Montagna - Via Torino 110 - 30172 Venezia/Mestre entilocaliservizielettorali@pec.regione.veneto.it

Table 7.1. *Ex-situ* conservation status for each species.

Species	Field collections	Germplasm bank

Scientific Name	Native (N) or Non-Native (E) Hybrid (H)	Collections, provenance or progeny tests, arboreta or conservation stands	Clone banks	Seed banks
		N. stands	N. Banks	N. Banks
Abies alba	N	8		
Abies bornmuelleriana	E	1		
Abies cephalonica	E	5		
Abies equi-trojani	E	1		
Abies nebrodensis	N	2	2	1
Abies nordmanniana	E	1		
Acer campestre	N	4		4
Acer cappadocicum subsp. lobelii	N			1
Acer platanoides	N			2
Acer pseudoplatanus	N			8
Alnus glutinosa	N			2
Alnus incana	N			1
Carpinus betulus	N			9
Carpinus orientalis	N			1
Castanea sativa	N	3	1 arc*	1
Cedrus atlantica	E	5	1	
Cedrus libani	E	4		
Celtis australis	E			3
Cercis siliquastrum	E			1
Cornus mas	N			4
Cornus sanguinea	N			5
Corylus avellana	N			1
Cupressus sempervirens	N	2	2	
Cupressus sempervirens x dupreziana	H	2		
Cupressus spp 21 species	E	2		
Eucalyptus spp 54 species	E	1		
Eucalyptus hybrids	E		1	
Fagus sylvatica	N			5
Fraxinus angustifolia	N			1
Fraxinus excelsior	N			7
Fraxinus ornus	N			6
Juglans nigra	E	4	1	
Juglans regia	N	11	2	1
Juglans nigra x regia	H	2		1
Larix decidua	N	2		6
Ligustrum vulgare	N			3
Malus sylvestris	N			3
Ostrya carpinifolia	N			3

Paulownia tomentosa	E			1
Picea abies	N	2		
Picea excelsa	N			4
Pinus brutia	N	9		
Pinus cembra	N			1
Pinus halepensis	N	12		
Pinus eldarica	E	2		
Pinus leucodermis	N			1
Pinus mugo	N			3
Pinus nigra austriaca	N			2
Pinus pinaster	N	16		
Pinus pinea	N			1
Pinus mugo pumilio	N			1
Pinus sylvestris	N	1		
Populus deltoides	E		12	
Populus × canadensis, P. × interamericana and other hybrids	H		29	
Populus nigra	N		10	1
Populus alba	N	2	3	
Prunus avium	N	12	3 arc* 19	3
Prunus cerasifera	N			2
Prunus cerasus	N			3
Prunus mahaleb	N			4
Prunus serotina	E	1		
Prunus webbii	N			1
Pseudotsuga menziesii	E	9		
Quercus cerris	N	3		
Quercus ilex	N			2
Quercus pubescens	N			1
Quercus robur	N	2		5
Quercus suber	N	3		
Robinia pseudoacacia	E	4		
Salix alba	N		2	
Salix crataegifolia	N			1
Sorbus aria	N			4
Sorbus aucuparia	N			4
Sorbus domestica	N			1
Sorbus torminalis	N	3		3
Taxus baccata	N			1
Tilia cordata	N			1
Tilia platyphyllos	N			1
Ulmus minor	N		1	
Ulmus glabra	N		1	2

Ulmus leavis	N		1	
Ulmus pumila	N		1	1
U.glabra x U. minor	N H		1	
U. minor x U. pumila	H		1	

*Clonal archive; Seed Bank: seed conservation sites

Table 7.2. Number of *ex-situ* accessions and clones per single species, (prov = provenances, prog = progenies, gen = genotypes). Note: Seed Bank/N. accessions: number of accessions conserved in seed banks.

Species		**Provenance's collections/ progeny tests/conservation stands**	**Clone banks**	**Seed banks**
Scientific Name	Native (N) or non Native (E)	N. accessions	N. clone	N. accessions
Abies alba	N	26 prov		
Abies bornmuelleriana	E	4 prov		
Abies cephalonica	E	11 prov		
Abies equitrojani	E	1 prov		
Abies nebrodensis	N	1 prov	29	1
Abies nordmanniana	E	3 prov		
Acer campestre	N	7 prov		
Acer cappadocicum subsp. lobelii	N			8
Acer platanoides	N			2
Acer pseudoplatanus	N			8
Alnus glutinosa	N			2
Alnus incana	N			1
Carpinus betulus	N			9
Carpinus orientalis	N			1
Castanea sativa	N	8 prov	345	1
Cedrus atlantica	E	14 prov 35 prov	140	
Cedrus libani	E	12 prov		
Celtis australis	E			3
Cercis siliquastrum	E			1
Cornus mas	N			4
Cornus sanguinea	N			5
Corilus avellana	N			1
Cupressus sempervirens	N	128 prov	8000	
Cupressus sempervirens x dupreziana	H	300 gen		
Cupressus spp 21species	E	47 prov		
Eucalyptus spp 54 species	E	340 prov		
Eucalyptus hybrids	E		17	
Fagus sylvatica	N			5
Fraxinus angustifolia	N			1

Fraxinus excelsior	N			7
Fraxinus ornus	N			6
Juglans nigra	E	18 prov	36	
Juglans regia	N	84 prog 38 prov	73	1
Juglans nigra x regia	H	12 prog	12	
Larix decidua	N	37 prov		6
Ligustrum vulgare	N			3
Malus sylvestris	N			3
Ostrya carpinifolia	N			3
Paulownia tomentosa	E			1
Picea abies	N		16	
Picea excelsa	N			4
Pinus brutia	N	41 prov		
Pinus cembra	N			1
Pinus halepensis	N	9 prog 41 prov		
Pinus eldarica	E	1 prov		
Pinus leucodermis Antoine	N			1
Pinus mugo	N			3
Pinus nigra var. austriaca	N			2
Pinus pinaster	N	41 prov 106 progs 274 gen		
Pinus pinea	N			18
Pinus sylvestris	N	12 prov		
Populus deltoides	E		179	
Populus × canadensis, P. × interamericana and other hybrids	H		182	
Populus nigra	N	7 prov	561	
Populus alba	N	280 prov	257	
Prunus avium	N	63 prog	153 186	3
Prunus cerasifera	N			2
Prunus cerasus	N			3
Prunus mahaleb	N			4
Prunus serotina	E	10		
Prunus webbii	N			3
Pseudotsuga menziesii	E	50 prog 118 prov		
Quercus cerris	N	12 prov		
Quercus ilex	N			2
Quercus pubescens	N			1
Quercus robur	N	15 prov		5
Quercus suber	N	22 prov 34 prog		
Robinia pseudoacacia	E	146 prov	4	

Salix alba	N	n. a.	590	
Salix crataegifolia	N			1
Sorbus aria	N			4
Sorbus aucuparia	N			4
Sorbus domestica	N			1
Sorbus torminalis	N	21 prov 162 prog		3
Taxus baccata	N			1
Tilia cordata	N			1
Tilia platyphyllos	N			1
Ulmus minor var. canescens	N		153	
Ulmus glabra	N		7	2
Ulmus leavis	N		4	
Ulmus pumila	E		5	1
U.glabra x U. minor	N H		8	
U. minor x U. pumila	H		10	

Table 7.3. Area of *ex-situ* conservation for each species

Tree species	**Area (ha)**
Abies alba	6.00
Abies bornmuelleriana	2.00
Abies cephalonica	7.00
Abies equi-trojani	1.00
Abies nebrodensis	2.00
Abies nordmanniana	1.00
Acer campestre	6.00
Acer pseudoplatanus	2.00
Alnus cordata	12.00
Castanea sativa	11.00
Cedrus atlantica	6.80
Cedrus deodara	262.30
Cedrus libani	4.32
Cupressus sempervirens	24.00
Eucalyptus spp	2.00
Juglans nigra	6.00
Juglans nigra x regia	1.50
Juglans regia	6.00
Larix decidua	4,00
Pinus pinaster	28.44
Pinus sect. halepensis	10.00
Pinus sylvestris	8.00
Populus alba	2.00
Populus nigra	12.90

Prunus avium	14.00
Prunus serotina	4.00
Pseudotsuga menziesii	259.00
Quercus cerris	6.00
Quercus ilex	2,00
Quercus robur	2,00
Quercus suber	2.00
Robinia pseudoacacia	8.00
Salix alba	3.50
Sorbus torminalis	2.00
Ulmus spp.	1.00
Arbutus unedo, Erica arborea, Myrtus communis, Olea europaea, Phillyrea angustifolia, Phillyrea latifolia, Pistacia lentiscus, Rhamnus alaternus, Rosa sempervirens, Viburnum tinus	2.00

Table 7.4. Players and stakeholder involved with *ex-situ* conservation and use of forest genetic resources.

Name of institution	**Type of institution**	**Contact information**
Ministero delle politiche agricole, alimentari e forestali, MIPAAF	Government	Direzione Generale dell'Economia Montana e delle Foreste MIPAAF Via XX Settembre, 20 – 00185 Roma, Italia https://www.politicheagricole.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/12237 FRM-Italy@politicheagricole.it
Ministero della Difesa	Government	Ufficio per la Biodiversità (ex- Corpo Forestale dello Stato) Via Carducci, 5 – 00185 Roma, Italia http://www.carabinieri.it/arma/oggi/organizzazione/organizzazione-per-la-tutela-forestale-ambientale-e-agroalimentare/utcb-e-le-130-riserve-naturali
Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria, CREA	Research institution	Centro di ricerca per le foreste e il legno https://www.crea.gov.it/en/web/foreste-e-legno fl@crea.gov.it Viale S. Margherita, 80 – 52100 Arezzo, Italia
Consiglio Nazionale delle Ricerche CNR	Research institution	Institute for sustainable plant protection CNR IPSP http://www.ipsp.cnr.it/ direttore@ipsp.cnr.it Sede Secondaria Sesto fiorentino, Via Madonna del Piano 10 - 50019 Sesto Fiorentino (FI) Toscana, Italia
Università di Firenze	Research institution	Dipartimento di Scienze e Tecnologie Agrarie, Alimentari, Ambientali e Forestali DAGRI - sezione Foreste ambiente legno paesaggio FALP www.dagri.unifi.it dagri@pec.unifi.it Via San Bonaventura, 13 50145 FIRENZE, Italy
Università degli Studi della Tuscia	Research institution	Department for innovation in biological, agro-food and forest systems DIBAF https://www.unitus.it/it/dipartimento/dibaf dibaf@unitus.it Via San Camillo de Lellis s.n.c.01100
Università di Parma	Research institution	Dipartimento di Scienze Chimiche, della Vita e della Sostenibilità Ambientale http://scvsa.unipr.it - protocollo@pec.unipr.it

		Viale delle Scienze, 11/a - 43124 Parma (Italy)
Regione Abruzzo	Government	http://www2.consiglio.regione.abruzzo.it/leggi_tv/storico/2014/lr14003.htm Servizio Presidi Tecnici di Supporto al Settore Agricolo – DPD023 - Ufficio Direttiva Nitrati, Qualità dei Suoli, Coordinamento Servizi Vivaistici ed Agrimeteo (Cepagatti-Scerni) DPD023/002.
Regione Campania	Government	http://agricoltura.regione.campania.it/foreste/boschi_da_seme.html Direzione Generale per le Politiche Agricole Alimentari e Forestali - Unità Operativa Dirigenziale "Ufficio Centrale Foreste e Caccia dg.500700@pec.regione.campania.it; uod.500704@pec.regione.campania.it
Regione Friuli-Venezia Giulia	Government	http://www.regione.fvg.it/rafvg/cms/RAFVG/economia-imprese/agricoltura-foreste/foreste/FOGLIA10/ Istituzione e aggiornamento del registro dei materiali di base delle specie presenti nel territorio regionale: Direzione centrale risorse agroalimentari, forestali e ittiche - Servizio foreste e corpo forestale - indirizzo: UDINE - Via Sabbadini, 31 telefono: 0432555111 – corpoforestale@regione.fvg.it; PEC: corpoforestale@certregione.fvg.it. Controlli alla produzione e certificazione dei materiali forestali di moltiplicazione: ERSA - agenzia regionale per lo sviluppo rurale - Servizio fitosanitario e chimico, ricerca, sperimentazione e assistenza tecnica; indirizzo: POZZUOLO DEL FRIULI - Via Sabbatini, 5 - telefono: 0432529266. ersa@ersa.fvg.it; PEC: ersa@certregione.fvg.it.
Regione Lombardia	Government	https://www.regione.lombardia.it/wps/portal/istituzionale/HP/DettaglioRedazionale/servizi-e-informazioni/Imprese/Imprese-agricole/Boschi-e-foreste/normativa-boschi-e-foreste/registro-boschi-da-seme/registro-boschi-da-seme Direzione Generale: Agricoltura, Alimentazione e Sistemi verdi - Struttura: Sviluppo delle politiche forestali e della montagna PEC: agricoltura@pec.regione.lombardia.it
Regione Marche	Government	Servizio Politiche Agroalimentari - Posizione di Funzione Interventi nel settore forestale e dell'irrigazione e SDA di Ancona - Via Tiziano 44 - 60100 Ancona. PEC regione.marche.pfcsi@emarche.it
Regione Molise	Government	Dipartimento II - Risorse finanziarie Valorizzazione ambiente e risorse naturali Sistema regionale autonomie locali. Servizio Fitosanitario Regionale Tutela e valorizzazione della montagna e delle foreste, biodiversità e sviluppo sostenibile. Ufficio Gestione Rete Natura 2000 e VincA, Alberi monumentali, Conservazione genetica forestale e Controllo materiale di moltiplicazione.
Regione Piemonte	Government	https://www.regione.piemonte.it/web/temi/ambiente-territorio/foreste/servizio-informativo-forestale-regionale-sifor Direzione Ambiente, Energia e Territorio - Settore Foreste - foreste@cert.regione.piemonte.it - all'interno della Direzione regionale per la materia Vivaistica forestale (in senso lato) operano due strutture: a) Settore Foreste (Torino), per gli aspetti normativi - regolamentari, il Registro dei materiali di base, le licenze alla produzione e commercializzazione; b) Settore Tecnico di Biella e Vercelli (Vercelli), per il coordinamento dei vivai forestali di proprietà regionale

Regione Autonoma della Sardegna	Government	http://www.sardegnaambiente.it/documenti/19_173_20141106111950.pdf a) Assessorato della difesa dell'ambiente - Servizio tutela della natura e politiche forestali (coordinamento generale e andamento delle disposizioni - PEC difesa.ambiente@pec.regione.sardegna.it); b) Corpo forestale e di vigilanza ambientale - Direzione Generale - Servizio di vigilanza e coordinamento tecnico (PEC cfva. vigilanza@pec.regione.sardegna.it); c) Assessorato dell'agricoltura e riforma agro-pastorale - Direzione generale dell'agricoltura e riforma agro-pastorale - Servizio sostenibilità e qualità delle produzioni agricole e alimentari (PEC agricoltura@pec.regione.sardegna.it)
Regione Sicilia	Government	http://pti.regione.sicilia.it/portal/page/portal/PIR_PORTALE/PIR_LaStrutturaRegionale/PIR_Assessoratoregionaledelterritorioedellambiente/PIR_Comandocorpoforestale/PIR_Areetematiche/PIR_Altricontenuti/PIR_Controllovivaismo Comando Corpo Forestale Regione Sicilia - Servizio 5 Interventi Opere pubbliche tutela ed economia montana - Unità operativa 14 Vincolo Idrogeologico PEC: comando.corpo.forestale@certmail.regione.sicilia.it
Regione Toscana	Government	Direzione Agricoltura e Sviluppo Rurale Settore Forestazione. Usi Civici. Agroambiente Via di Novoli 26 – 50127 Firenze PEC: regionetoscana@postacert.toscana.it
RIBES – Rete Italiana Banche del Germoplasma	Interregional Institution	RIBES: Rete Italiana Banche del germoplasma per la conservazione *ex-situ* della flora spontanea italiana Associazione di promozione sociale con sede in Trento, Via Calepina 14, CP 393 CAP 38100 *bonomi@mtsn.tn.it*; sito www.reteitalianagermoplasma.it
Centro Regionale Castanicoltura del Piemonte	Government /private	Centro Regionale Castanicoltura del Piemonte, Gambarello 23, 12013 Chiusa di Pesio (CN) University of Turin - Via Verdi, 8 - 10124 Torino info@centrocastanicoltura.org https://centrocastanicoltura.org/en/

Table 8.1. Main use and purposes in Italy of different FGR (examples).

RGF - Main purpose	**Species**
High quality wood production	*Acer platanoides*, *Acer pseudoplatanus* L., *Abies alba* Mill., *Castanea sativa* Mill. *Juglans regia* L., *Juglans nigra* L., *Picea abies* (L.) Karst., *Prunus avium* L., *Pseudotsuga menziesii* Franco¸ *Quercus robur* L., *Q. petraea* Liebl.,
Pulp	*Populus* spp., *Eucalyptus* spp., *Robinia pseudoacacia*
Wood for energy production (fuel)	*Quercus* spp., *Fagus sylvatica L.*
Reforestation	Please, see list of species in Annex 1 to Legislative Decree n. 386/2003.
Social or cultural importance	*Abies alba* Mill., *Cupressus sempervirens* L., *Fagus sylvatica* L., *Pinus pinea* L., *Pinus pinaster* Aiton, *Ulmus* spp., *Myrtus communis* L., *Ostrya carpinifolia* Scop., *Taxus baccata* L., *Ulmus laevis* L.

Wood production and soil protection, nitrogen fixing	*Alnus cordata* (Loisel.) Desf., *Alnus glutinosa* (L.) Gaertner, *Alnus incana* Gaertner, *Carpinus betulus* L., *Robinia pseudoacacia*
Biodiversity conservation: extinction risk/endangered species	*Abies nebrodensis* (Lojac.) Mattei (IUCN red list), *Betula pendula* Roth, *Betula aetnensis* Raf., *Betula pubescens* Ehrh., *Pinus leucodermis* Antoine, *Zelkova sicula* L. (IUCN red list)
Non-wood forest products NWF (food, mycorrhization with truffle, fodder, pharmaceutical industry	*Castanea sativa* Mill., *Corylus avellana* L., *Ficus carica* L., *Fraxinus oxycarpa* Willd., *Juniperus communis, Picea abies* (L.) Karst., *Pinus laricio* (Poir.) Maire, *Pinus brutia* Ten., *Pinus cembra* L., *Pinus excelsa* (*P.wallichiana*) A. B. Jacks, *Pinus halepensis* Mill., *Pinus pinea* L., *Quercus suber* L., *Ulmus* spp., *Taxus baccata* L., *Quercus* spp., *Carpinus* spp., *Ceratonia siliqua* L., *Erica* spp., *Eucalyptus* spp., *Juglans regia* L., *Myrtus communis* L.
Landscape	*Acer* spp., *Sorbus* spp., *Robinia pseudoacacia* L., *Abies alba* Mill., *Fagus sylvatica* L., *Quercus* spp., *Ceratonia siliqua* L., *Cytisus scoparius* L., *Genista aetnesis* DC., *Larix decidua* Mill., *Picea abies* (L.) Karst., *Pinus nigra* Arnold, *Pinus sylvestris* L.
Ornamental	*Abies* spp., *Picea* spp., *Celtis australis* L., *Larix decidua, Platanus hybrida* Brot., *Platanus orientalis* L., *Sorbus* spp., *Viburnum* spp., *Ulmus* spp., *Viburnum* spp., *Tilia* spp., *Prunus padus* L., *Prunus mahaleb* L., *Populus tremula* L., *Cedrus* spp., *Genista aetnesis* DC., *Laburnum alpinum* (Mill.), *Laburnum anagyroides* Medik, *Nerium oleander* L.
Environmental protection and restoration	*Celtis australis* L., *Viburnum* spp., *Ulmus* spp., *Spartium junceum* L., *Sorbus* spp., *Salix* spp., *Quercus* spp., *Carpinus* spp., *Cedrus* spp., *Cercis siliquastrum* L., *Cytisus scoparius* L., *Olea oleaster* L., *Pinus nigra* Arnold, *Pinus uncinata* L.
Urban forestry	Please, see list of species in Annex 1 to Legislative Decree n. 386/2003.

Table 8.2. Annual quantity (Kg) of seed collected.

Species	**Seed Collected from 1st July 2018 to 30th June 2019**	**Seed Collected from 1st July 2017 to 30th June 2018**	**Seed Collected from 1st July 2016 to 30th June 2017**
Abies alba	318.5	0.0	0.0
Acer campestre	192.4	213.8	68.6
Acer obtusatum	0.5	0.0	0.0
Acer opulifolium	0.0	61.4	0.0
Acer platanoides	12.3	123.0	22.9
Acer pseudoplatanus	57.8	208.4	62.5
Alnus cordata	0.1	6.0	0.0
Alnus glutinosa	32.5	15.3	2.5
Alnus incana	0.7	3.7	4.2
Betula pendula	11.9	8.6	12.0

Betula pubescens	0.0	0.0	0.3
Carpinus betulus	143.9	248.0	68.6
Castanea sativa	1839.8	1688.9	440.7
Cedrus atlantica	0.0	0.0	0.5
Cedrus deodara	29.0	29.0	0.0
Cedrus libani	1.0	1.0	0.0
Cupressus sempervirens	96.7	101.9	0.0
Fagus sylvatica	149.3	128.0	363.8
Fraxinus angustifolia	37.9	88.2	5.5
Fraxinus excelsior	133.2	126.5	32.9
Fraxinus ornus	101.5	91.7	36.0
Juglans nigra	24.7	200.0	0.0
Juglans regia	255.4	142.1	108.5
Larix decidua	234.9	20.0	0.0
Ostrya carpinifolia	73.3	49.9	32.1
Paulownia spp.	160.9	1.5	0.0
Picea abies	296.4	3.0	0.0
Pinus cembra	24.0	0.0	0.0
Pinus halepensis	42.9	2.0	6.6
Pinus mugo	77.9	1137.0	10.8
Pinus nigra	3.9	0.0	8.2
Pinus pinaster	16.0	0.0	15.8
Pinus pinea	20.0	530.0	90.0
Pinus sylvestris	0.3	190.0	0.4
Populus alba	1.2	0.1	0.1
Populus nigra	0.1	12.1	0.7
Prunus avium	189.6	446.7	105.2
Prunus padus	27.4	55.7	16.0
Pyrus pyraster	53.1	481.0	72.0
Quercus cerris	2554.4	210.6	197.1
Quercus frainetto	80.0	0.0	36.0
Quercus ilex	1767.8	1599.4	909.9
Quercus macrolepis	50.0	0.0	140.0
Quercus petraea	341.5	726.0	146.3
Quercus pubescens	1430.6	1621.0	700.1
Quercus robur	1167.8	1444.7	25.0
Quercus rubra	101.7	163.0	0.0
Quercus suber	337.5	459.6	300.0
Quercus trojana	215.0	0.0	30.0
Robinia pseudoacacia	24.3	102.2	0.0
Salix alba	1.1	2.3	0.0
Sorbus aria	12.0	10.0	100.5
Sorbus aucuparia	174.2	134.7	186.9
Sorbus domestica	38.3	263.1	25.0
Sorbus torminalis	56.9	240.1	84.4
Tilia cordata	29.6	76.7	25.3
Tilia platyphyllos	42.9	64.4	13.3
Ulmus glabra	2.0	0.0	7.1

Ulmus minor	49.3	56.4	2.0
Ulmus pumila	8.1	5.0	0.0
Ulmus spp e ibridi	0.9	1.7	1.7
Populus tremula	0.3	0.0	0.0
olea europaea	23.0	70.0	0.0
Ulmus laevis	1.5	0.0	0.0
Q. coccifera	40.0	0.0	45.0
Crategus monogina	90.0	0.0	0.0
Celtis australis	0.2	0.0	0.0
Ginkgo biloba	0.3	0.0	0.0
Laurus nobilis	86.4	0.0	0.0
Ligustrum vulgare	75.0	0.0	0.0
Cercis siliquastrum	3.5	0.0	0.0
Phillyrea latifolia	111.3	0.0	0.0
Acer monspessulanum	1.0	0.0	0.0
Arbutus unedo	28.1	0.0	0.0
Carpinus orientalis	3.8	0.0	0.0
Ceratonia siliqua	268.0	0.0	0.0
Cistus incanus	0.3	0.0	0.0
Cistus salvifolius	0.3	0.0	0.0
Cornus mas	1.5	0.0	0.0
Cornus sanguinea	10.7	0.0	0.0
Coronilla emerus	1.3	0.0	0.0
Corylus avellana	40.0	0.0	0.0
Euonymus europaeus	1.0	0.0	0.0
Fraxinus oxycarpa	5.0	0.0	0.0
Ilex aquifolium	2.0	0.0	0.0
Myrtus communis	10.5	0.0	0.0
Pistacia lentiscus	53.4	0.0	0.0
Pistacia terebinthus	1.5	0.0	0.0
Prunus spinosa	8.0	0.0	0.0
Quercus morisii	10.0	0.0	0.0
Quercus virgiliana	485.0	0.0	0.0
Rhamnus alaternus	2.3	0.0	0.0
Rosa canina	5.5	0.0	0.0
Ruscus aculeatus	3.0	0.0	0.0
Juniperus oxycedrus	42.0	0.0	0.0
Juniperus turbinata	60.4	0.0	0.0
Rosmarinus officinalis	0.2	0.0	0.0
Quercus cogesta	80.0	0.0	0.0
Spartium junceum	10.8	0.0	0.0
Quercus calliprinos	50.0	0.0	0.0
Platanus orientalis	1.3	0.0	0.0
Chamaerops humilis	60.0	0.0	0.0
Total	14824.9	13665.0	4562.7

Table 8.3. Mean annual value of plant parts produced for the internal trade

Species	Average annual value of plant parts (N)
Abies alba	18865.3
Acer campestre	43408.7
Acer opulifolium	69.3
Acer platanoides	2122.0
Acer pseudoplatanus	28076.0
Alnus cordata	872.0
Alnus glutinosa	17773.7
Alnus incana	3496.0
Betula pendula	14543.3
Betula pubescens	3385.0
Carpinus betulus	55647.7
Castanea sativa	17559.7
Cupressus sempervirens	1586.7
Fagus sylvatica	44171.0
Fraxinus angustifolia	4192.7
Fraxinus excelsior	26525.3
Fraxinus ornus	18860.0
Juglans nigra	1040.7
Juglans regia	8708.7
Larix decidua	165683.7
Ostrya carpinifolia	55900.0
Picea abies	150790.3
Pinus cembra	52744.3
Pinus halepensis	1896.7
Pinus mugo	5737.0
Pinus nigra	241.7
Pinus pinea	6673.3
Pinus sylvestris	4921.7
Pinus uncinata	855.3
Populus alba	148337.3
Populus nigra	69364.0
Prunus avium	33173.3
Prunus padus	12414.7
Pseudotsuga menziesii	10418.7
Pyrus pyraster	7508.3
Quercus cerris	38897.7
Quercus frainetto	14533.3
Quercus ilex	50405.3
Quercus macrolepis	2233.3
Quercus petraea	9731.3

Quercus pubescens	55725.0
Quercus robur	43923.0
Quercus rubra	1211.7
Quercus suber	30220.0
Quercus trojana	833.3
Robinia pseudoacacia	25460.7
Salix alba	86243.0
Sorbus aria	3527.0
Sorbus aucuparia	17051.0
Sorbus domestica	2709.0
Sorbus torminalis	8159.7
Tilia cordata	14149.0
Tilia platyphyllos	4844.3
Ulmus glabra	383.3
Ulmus minor	11808.3
Ulmus pumila	4428.3
Ulmus spp and hybrids	3861.3
Salix caprea	36123.3
Populus nigra italica	11166.7
Populus and hybrids	16400.0
Noce spp	1527.7
Ulmus laevis	946.7
Populus traemula	390.0
Olea europea	37.3
Crategus monogina	210.0
Celtis australis	83.3
Ginkgo biloba	25.0
Laurus nobilis	250.0
Ligustrum vulgare	166.7
Rosmarinus officinalis	500.0
Phillyrea latifolia	40.0

Table 8.4. Number generation and area of seed orchards.

Species	Seed orchards*		
	Number	**Generation	Area (ha)
Abies nebrodensis	1	1	4
Juglans regia	3	2	3
Pinus brutia	1	1	3
Picea abies	2	2	2
Pinus pinaster	1	1	3
Pinus silvestris	1	1	4
Prunus avium	3	1	5

*Seed orchards are plantations specifically planted and managed for seed production, not natural seed stands.
**Generation refers to 1st, 2nd, 3rd, etc., breeding cycle.

Table 8.5. Quantities of poplar FRM (ramets) produced for national and EU trades and exported towards non-EU countries.

Species	Category	Trade	Quantity	Period
Populus spp.	Controlled	National and EU trade	306777	1st July 2016 - 30 June 2017
Populus spp.	Controlled	National and EU trade	378178	1st July 2017 - 30 June 2018
Populus spp.	Controlled	National and EU trade	1932835	1st July 2018 - 30 June 2019
Populus spp.	Controlled	non-EU trade	705074	(1st July 2018 - 30 June 2019

Table 9.1. Present activities of genetic improvement and breeding on the main forest trees species in Italy.

		Provenance trials		Progeny trials		Clonal testing and develop.	
Species	**Origin**	**Trials No.**	**Prov. No.**	**Trials No.**	**Families No.**	**Tests No.**	**Clones No.**
Abies cephalonica (Loudon)	E	2	10	3			
Acer campestre L.	N	4	7				
Alnus cordata (Loisel.) Duby	N	5	7	2	39.		
Castanea sativa (Mill.)	N	3	8			1	345
Cedrus atlantica (Endl.) Manetti ex Carrière	E	5	14	1	35	1	140
Cupressus sempervirens (L.)	N	2	128			12	8000
Cupressus sempervirens (L.) × *dupreziana* (A. Camus)	N				2	300	
Cupressus spp. (L.) (21 species)	N	2	47				
Eucalyptus spp. (L'Hér.) (54 species)	E	1	340			1	17
Juglans nigra (L.)	E	4	18			1	36
Juglans regia (L.)	N	5	38	6	84	2	73

Juglans nigra × *regia*	NE			1	12	1	12
Juglans microcarpa (Berl.)	E	1	1				
Pinus brutia (Ten.) Holmboe	N	9	41				
Pinus halepensis (Mill.)	*N*	12	41		9		
Pinus pinaster (Aiton) p., progenies; g., genotypes	N	16	41	9	106 p. 274 g.		
Pinus sylvestris (L.)	N	1	12 prov				
Populus alba (L.)	N	2	108	-	73	4	5160
Populus deltoides (Bartr. ex Marsh.)	E	1	420	-	12	2	800
Populus nigra (L.)	N	1	690	-	21	4	4570
Populus spp (L.). interspecific hybrids	N	1	250	-	44	8	10500
Prunus avium (L.)	N	12			63	22	339
Pseudotsuga menziesii (Mirb.) Franco	E	9	118	1	50		300
Robinia pseudoacacia (L.)	E	4	160			2	4
Salix spp. (L.) (40 species)	N					2	590
*Sorbus torminalis (*L.) Crantz)	N	3	21	2	162		
Ulmus minor (Mill.)	N					1	153
Ulmus glabra (Huds.)	N					1	7
Ulmus laevis (Pall.)	N					1	4
Ulmus pumila (L.)	N					1	5
U.glabra (Huds.) × *U. minor* (Mill.)	N					1	8
U. minor (Mill.) × *U. pumila* (L.)	N					1	10

Table 9.2 Main Forest species with active deployment for the establishment of seed orchards or mass propagation using vegetative techniques (See also questionnaire, point 26, part 1).

Species	**Generation and clones**
Alnus cordata	2nd gen.
Castanea sativa	2nd gen. and clones (Qualified FRM) *
Cedrus atlantica	2nd gen. and clones
Cupressus spp.	1st gen. and clones
Eucalyptus spp.	2nd gen.and clones
Fraxinus excelsior	1st gen. (Qualified FRM) *
Juglans spp.	2nd gen. (Qualified FRM) *
Pinus brutia	1st gen. (Qualified FRM) *
Pinus halepensis	2nd gen.
Pinus pinaster	2nd gen.
Populus spp.	Multiple gen. and clones (Controlled FRM) *
Prunus avium	2nd gen. and clones (Qualified FRM) *
Pseudotsuga menziesii	2nd gen. and grafted clones
Robinia pseudoacacia	Clones
Salix spp.	Multiple genotypes and clones
Ulmus spp.	Multiple genotypes and clones

* Categories of Forest Base Material according to the National Register of Forest Base Material.

Table 9.3. Uses and traits of tree improvement and breeding in Italy.

Species	***Uses***	***Traits***	***Ref. # (see box below)***
Abies cephalonica	Wood production, forestation, and afforestation activities	Growth and tree form, adaptation, tolerance to abiotic stress	1, 2, 24, 38
Alnus cordata	Wood production, forestation, and afforestation activities	Growth, morphological traits**, adaptive traits***	1, 2

Castanea sativa	Wood production, NWFP*	Growth, morphological traits**, adaptive traits***, pest and disease resistance, fruit quality and productions	1, 2, 6, 60
Cedrus atlantica	Wood production, forestation and afforestation activities, others	Growth, morphological traits**, adaptive traits***	1, 2, 35
Cupressus sempervirens	Wood production, forestation activities	Growth, morphological traits**, adaptive traits***	1, 2, 15
Cupressus sempervirens × *dupreziana*	Wood production, forestation activities	Growth, morphological traits**, adaptive traits***	1, 2
Cupressus spp.	Wood production, forestation activities	Growth, morphological traits**, adaptive traits***	1, 2, 15
Eucalyptus spp.	Wood production, Pulpwood, NWFP*	Growth, morphological traits**, adaptive traits***	1, 2
Eucalyptus hybrids	Wood production, Pulpwood, NWFP*	Growth, morphological traits**, adaptive traits***	1, 2, 47, 48
Juglans nigra	Wood production, forest tree farming	Growth, morphological traits**, adaptive traits***	1, 2, 4, 32, 54, 55
Juglans regia	Wood production, forest tree farming, NWFP*	Growth, morphological traits**, adaptive traits***	1, 2, 4, 23, 28, 32, 54, 55
Pinus brutia	Wood production, forestation and afforestation activities	Growth, morphological traits**, adaptive traits***	1, 2, 11, 25, 30, 31
Pinus halepensis	Wood production, forestation, and afforestation activities	Growth, morphological traits**, adaptive traits***	1, 2, 7, 11, 31
Pinus nigra	Wood production, forestation and afforestation activities	Growth, morphological traits**, adaptive traits***	1, 2
Pinus pinaster	Wood production, forestation, and afforestation activities	Growth, morphological traits**, adaptive traits***	1, 2
Pinus sylvestris	Wood production, forestation, and afforestation activities	Growth, morphological traits**, adaptive traits***	1, 2

Populus alba	Wood production, pulpwood, fuelwood, and afforestation in sensitive areas	Growth, rooting capability, morphological traits**, adaptive traits***, pest and Disease resistance	1, 2, 12
Populus deltoides	Wood production, intensive forest tree farming, for industrial uses (plywood and other wood-based panels)	Growth, rooting capability, morphological traits**, adaptive traits***, pest and disease resistance	1, 2, 8, 12, 13, 52, 56
Populus nigra	Wood production, afforestation in sensitive areas and environmental requalification	Growth, morphological traits**, adaptive traits***, pest and disease resistance	1, 2, 3, 10, 18, 34, 41, 43, 57
Populus spp. interspecific hybrids	Wood production, intensive forest tree farming, for industrial uses (plywood and other wood-based panels)	Growth, morphological traits**, adaptive traits***, pest and disease resistance	1, 2, 5, 8, 12, 13, 14, 42, 52, 56
Prunus avium	Wood production, , forest tree farming, forestation and afforestation activities	Growth, morphological traits**, adaptive traits***	1, 2, 16, 17, 21, 26, 49, 50, 51
Pseudotsuga menziesii	Wood production, pulpwood, intensive forest tree farming	Growth, morphological traits**, adaptive traits***	1, 2, 27
Quercus robur	Wood production, forestation and afforestation activities, intensive forest tree farming, other	Growth, morphological traits**, adaptive traits***	1, 2
Quercus suber	NWFP*	Growth, morphological traits**, adaptive traits***	1, 2
Robinia pseudoacacia	Wood production, pulpwood, fuelwood, intensive forest tree farming	Growth, morphological traits**, adaptive traits***	1, 2
Salix spp.	Wood production, Forestation, and afforestation activities	Growth, morphological traits**	1, 2, 9, 40, 59
Sorbus torminalis	Wood production, forest tree farming	Growth, morphological traits**, adaptive traits***	1, 2
Ulmus minor	Wood production, forestation, and afforestation activities	Growth, morphological traits**, adaptive traits***, pest and disease resistance	1, 2, 36, 37, 44, 53, 58
Ulmus glabra	Timber, forestation, and afforestation activities	Growth, morphological traits**, adaptive traits***, pest and disease resistance	1, 2, 37, 53, 58
Ulmus laevis	Timber, forestation, and afforestation activities	Growth, morphological traits**, adaptive traits***, pest and disease resistance	1, 2, 53, 58

Ulmus pumila	Timber, forestation, and afforestation activities, other	Growth, morphological traits**, adaptive traits***, pest and disease resistance	1, 2, 37, 44, 53, 59
U.glabra × *U. minor*	Timber, forestation, and afforestation activities	Growth, morphological traits**, adaptive traits***, pest and disease resistance	1, 2, 44, 53, 59
U. minor × *U. pumila*	Timber, forestation, and afforestation activities	Growth, morphological traits**, adaptive traits***, pest and disease resistance	1, 2, 37, 44, 53, 59

** NWFP: Non-Wood Forest Products*

*** Morphological traits: Stem form, basal sweep, branch angle, branch thickness, apical dominance (only for young conifer polycyclism), forking.*

**** Adaptive traits and phenology traits: bud break, leaf phenology, flowering phenology, fruit phenology, hardening, drought resistance, late frost resistance, chilling requirement, shoot elongation, shoot frost hardiness, cambial activity.*

Box of References relevant to traits in Table 9.3 (4th column).

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Table 10.1. Modalities of FGR conservation.

Management		***Location***	
		in-situ	***ex-situ***
Dynamic		Natural populations	Plantations
Static		Individual tree	Germplasm banks, Archives, dendrological collections, etc.

Table 10.2. List of Regional stakeholders and relevant legislation.

Regional Authority	**Legislative reference**	**Regional rules e/o PMPF, Prescriptions of principle and forestry police**	**Implementation of EU DIR 105/1999 o D.Lgs 386/03**	**Notes on FGR management**
Valle d'Aosta	L.R. 4/1958	PMPF, Prescriptions of principle and forestry police del R.D.L.3267/1923	no	n.a.
Piemonte	L.R. 4/2009	Forest Regional regulation n. 8/R/2011 e ss.mm.ii.	yes	Art. 5 (forest nursery) Art. 13 (Forest regulation) Section III (protection of the genetic heritage of native tree and shrub species and forest nursery production).

				Annex D of the Regulation (List of sporadic species). FBM Regional List established
Liguria	L.R. 4/1999	Regional regulation 1/1999	no	Art. 4 (Typology of interventions), art. 13 (Regional Forest nurseries)
Lombardia	L.R. 31/2008	Regional regulation 5/2007	yes	Art. 53 (Basic forest and forest reproductive materials). Art. 27 (Collection of FRM and seed stands) and 51 (Plant material) of the Regional Regulations. FBM Regional Register established
Prov. Autonoma di Trento	L.P. 11/2007	Implementing regulations. D.P. 51-158 / 2008	SI	Chapter III of the L.P. FBM Regional List established
Prov. Autonoma di Bolzano	L.P. 21/1996	Presidential Decree of the Provincial Council 29/2000	Si	Chapter VI (FRM) of the L.P FBM Regional List established
Veneto	L.R. 52/1978 integrated with L.R. 5/2005	PMPF, Prescriptions of principle and forestry police 51/2003 DGR 3263 of15/10/2004	SI	Art. 28 of L.R. FBM Regional Register established
Friuli-Venezia-giulia	L.R. 9/2007	Forest regulation n. 274/2012	SI	Section IV (Forest nursery and FRM). The FBM Regional List has not been established even if there is a list of seed woods
Emilia-Romagna	L.R. 30/1981 and following. L.R. 10/2007 implementing 386/03)	PMPF, Prescriptions of principle and forestry police, D.G.R. 182/1995	SI	FBM List established
Toscana	L.R. 29/2000	Regional regluation 48/2003	SI	CAP III (FRM) of the L.R. Art. 12 Regulations (Protection of biodiversity). Established FBM Regional List
Marche	L.R. 6/2005	PMPF, Prescriptions of principle and forestry police, D.G.R. 2585/2001	SI	Art. 14 (Regional book of seed stands), art. 17 (Regional Forest nurseries) and 20 (Protection of tall trees) L.P. 21/1996 of the R.R. Established FBM Regional Register
Umbria	L.R. 28/2001	Regolamento Regionale 11/2012	SI	Title V of the L.R. Title X of the Regulation Established FBM Regional Register
Abruzzo	L.r. 3/2014	L 3/2014 and PMPF, Prescriptions of principle and forestry police, 43/1965 at province level.	SI	Chapter IV art. 57 to 62. The drafting of management regulations or specific interventions for FBMs are not envisaged. Established FBMs Regional List.
Molise				
Lazio	L.R. 39/2002 L.R. 3/2010	Regional regulation 7/2005	Si	Art. 49 (Stands intended for the protection of biodiversity and germplasm) of the regulation
Campania	L.R. 11/1996	PMPF, Prescriptions of principle and forestry police. Annex C della L.R.	SI	Artt. 2, 5, 7, 8 and 9

Puglia	L.R. 18/2000	Regional regulatin 10/2009	SI	Art. 4 (Aims)
Basilicata	L.R. 42/1998. D.G.R. n.247 of 26 Ferbruary 1998, implementing lgs. decree 386/03	DGR n. 956/2004	SI	Art. 2 L.R (intervention sectors)
Calabria	L.R. 45/2012	PMPF, Prescriptions of principle and forestry police, D.G.R. 218/2011	SI	Articles 2, 16 and 17 where forest nurseries are considered
Sicilia	L.R. 271/2016	PMPF, Prescriptions of principle and forestry police at province level		
Sardegna	L.R. 8/2016	PMPF, Prescriptions of principle and forestry police, n. 24/CFVA/2006	Si	Art. 2 (purposes) and art. 23 (Forest nursery) of the L.R.

Table 11.1. Institutions involved with conservation and use of forest genetic resources.

Name of institution	**type of institution**	**activities or programs**	**contact information**
Ministry of Agriculture, Food and Forest Policies	government	Coordination of policies on FGR and FRM management	Ministero delle Politiche agricole, alimentari e forestali - Direzione generale dell'Economia montana e delle foreste, via XX settembre, 20 - 00187 Roma, Italia. E-mail: FRM-Italy@politicheagricole.it
Ministry of Agriculture, Food and Forest Policies	government	RGV FAO international Treaty	Dr. Vincenzo Montalbano v.montalbano@politicheagricole.it MiPaaf, via XX settembre, 20 - 00185 Roma, Italia
CREA FL, Consiglio per la ricerca in agricoltura e l'economia agraria, Centro di ricerca foreste e legno	Research body	Conservation *in situ* and *ex situ* and breeding, Research, and experimentation on FGR	Dr. Maria Cristina Monteverdi, mc.monteverdi@crea.gov.it Dr. Giovanbattista de Dato, giovanbattista.dedato@crea.gov.it CREA FL, Viale S. Margherita, 80 - 52100 Arezzo, Italia
CNR IBBR Consiglio Nazionale delle Ricerche, Istituto di Bioscienze e biorisorse,	Research body	Genetics	Dr. Giovanni Giuseppe Vendramin direttore@ibbr.cnr.it CNR IBBR, via Madonna del Piano, 10, Sesto Fiorentino (Firenze)
CNR IRET Consiglio Nazionale delle Ricerche, Istituto di Ricerche sugli Ecosistemi Terrestri	Research body	Biodiversity of Forest Ecosistems at gene, population, species and community level	Dr. Carlo Calfapietra (carlo.calfapietra@cnr.it) Via G. Marconi n.2 Porano TR 05010 Italia
CNR IPSP – Consiglio Nazionale delle Ricerche, Institute for Plant Protection	Research body	Conservation *in situ* and *ex situ* and breeding, Research, and experimentation	Dr. Mauro Centritto centritto@cnr.it Via Madonna del Piano 10 - 50019 Sesto Fiorentino FI Toscana

Università di Firenze - GESAF	Research body	FRM testing and breeding	Prof. Alberto Maltoni alberto.maltoni@unifi.it Via San Bonaventura, 13 - 50145 FIRENZE
Università di Padova - TESAF	Research body	Conservation in situ and *ex situ* and breeding, Research and experimentation	Prof. Raffaele Cavalli raffaele.cavalli@unipd.it viale dell'Università 16, 35020 Legnaro (PD)
Università degli Studi della Tuscia - DIBAF	Research body	Conservation *in situ* and *ex situ* and breeding, Research and experimentation	Prof. Maurizio Sabatti m.sabatti@unitus.it Via San Camillo de Lellis s.n.c.01100
Università degli Studi di Torino- Dipartimento di Scienze Agrarie, Forestali e Alimentari DIVAPRA	Research body	Conservation in situ and ex situ and breeding, Research and experimentation	Prof Sergio Lanteri sergio.lanteri@unito.it Dott. Piero Belletti piero.belletti@unito.it Largo Paolo Braccini, 2 (già Via Leonardo da Vinci, 44) 10095 GRUGLIASCO (TO)
RIBES – rete Italiana Banche del Germoplasma	Interregional Institution	Conservation *ex situ*	RIBES: Rete Italiana Banche del germoplasma per la conservazione Ex-Situ della flora spontanea italiana Associazione di promozione sociale con sede in Trento, Via Calepina 14, CP 393 CAP 38100 bonomi@mtsn.tn.it; sito www.reteitalianagermoplasma.it
Regions: https://www.politicheagricole.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/16654			