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

COUNTRY REPORT

GREECE

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PREFACE

ABBREVIATIONS AND ACRONYMS

AFLPs: Amplified Fragment Length Polymorphisms
AUTH: Aristotle University of Thessaloniki
CFSW: Central Forest Seed Warehouse
CITES: Convention on International Trade in Endangered Species
DNA: Deoxyribonucleic Acid
DNB: Dothistroma Needle Blight
EC: European Commission
EEC: European Economic Community
EN: Endangered
ESF: European Social Fund
EUFGIS: European Information System on Forest Genetic resources
EUFORGEN: European Forest Genetic Resources Program
EUNIS: European University Information Systems
FAO: Food and Agriculture Organization
FGR: Forest Genetic Resources
FM: Forest Management
FRAXIGEN: Ash for the future: defining European ash populations for conservation and regeneration
GCUs: Gene Conservation Units
GIS: Geographic Information Systems
ICP: International Co-operative Programme
IPBGR: Institute of Plant Breeding and Genetic Resources
ISSR: Inter-Simple Sequence Repeat
IUCN: International Union for Conservation of Nature
JUNICOAST: Actions for the conservation of coastal dunes with *Juniperus* spp. in Crete and the South Aegean (Greece)
LIFEGENMON: LIFE for European Forest Genetic Monitoring System

MAICh: Mediterranean Agronomic Institute of Chania
NFI: National Forest Inventory
NGOs: Non-Governmental Organizations
NSPF: National Strategic Plan for Forests
QTL: Quantitative Trait Locus
UNDP: United Nations Development Program
SACs: Special Areas of Conservation
SCIs: Sites of Community Importance
SSR: Simple Sequence Repeat

EXECUTIVE SUMMARY

Greece is a valuable “hot spot of biodiversity” due to unique biogeographical and topographical characteristic in relation to the climatic conditions. Greece is situated in the eastern side of Mediterranean basin in southern-east part of Europe. It has a total area of 131,957 Km^2 of which 106,777 represent its continental mainland and 25,166 its islandic part. In Greece, forest land and landscapes covers 6.539.000 ha, from which 30.3% (3.903.000 ha) are forests and 20,4% (2.636.000 ha) are forest landscapes. In the Hellenic forest 400 forest trees species are growing and the composition of the forest is 42% evergreen broadleaves, 20% noble broadleaves and 38% conifers. Forest Genetic Resources (FGR) in Greece are a huge valuable heritage. The majority of Greek forest are public and sustainable forest management is being implemented by local authorities of public forest services in Greece under criteria in order to assure forest survival, regeneration, adaptation and longevity. Furthermore, in Greece there are 443 areas in the European network Natura 2000, which are divided to 202 Special Areas of Conservation (SACs) and 241 areas as Habitats Directive requires Sites of Community Importance (SCIs). The total area protected from Natura 2000 is about 4,300,000 ha. Nowadays, Hellenic forests face a serious of abiotic and biotic disturbances under the climatic changes which are already apparent in the Mediterranean area. It is important though under all these threats to protect, conserve and maintain forest genetic resources which are the basis of biodiversity; as genetic diversity is the basis for the diversity of species, forests and ecosystems. Many efforts have been accomplished so far in Greece for conservation of “ex situ” and “in situ” of important genetic material of different species. In the current report, we present current situation of protection and

management of FGR as long as strengths, weakness and opportunities for Greece in order to protect, maintain and conserve FGR Hellenic heritage.

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

1.1 The role of forests and the forest sector in the national economy

Greece is situated in the eastern side of Mediterranean basin in southern-east part of Europe. It has a total area of 131,957 Km^2 of which 106,777 represent its continental mainland and 25,166 its islandic part. Its unique biogeographical and topographical characteristic in relation to the climatic conditions are responsible for the characterization of Greece as a valuable “hot spot of biodiversity” (Aravanopoulos et al., 2019; Dernegi, 2010).

In Greece, forest land and landscapes covers 6.539.000 ha, from which 30.3% (3.903.000 ha) are forests and 20,4% (2.636.000 ha) are forest landscapes according to State of Europe’s Forests 2015 (Status and Trends in Sustainable Forest Management in Europe). In the Hellenic forest 400 forest trees species are growing and the composition of the forest is 42% evergreen broadleaves, 20% noble broadleaves and 38% conifers. There are two main categories concerning the property of Greek forests: a) Public forests and b) Private forests. According to State of Europe’s Forests 2015, in Greece from 1990-2015 there was an increment of 0.67 % for forest lands. Furthermore, in the latest report of FAO for the 2020 Global Forest Resources Assessment increased the total forest area from 3.299 ha to 3.902 ha in the period 1990-2020.

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

In 2018, a National Strategic Plan for Forests was voted as a Law (FEK 5351/28/11/2018) and published in the Official Gazette of the Government with a horizon of 20 years (2018-2038). The main target that was adopted was “Preserve sustainability and increase the contribution of forest ecosystems in the country’s economy through multifunctionality, adaptability and enhancement of socio-economic role, under the prism of climate change". In the same National Strategic Plan, it is mentioned that the main economic benefits from forest areas come from the production of timber, and non-timber products such as resin, mushrooms, honey, aromatic and pharmaceutical plants. Another benefit from forest ecosystems is safeguarding biodiversity. It is remarkable that in Greece there are 443 areas in the European network Natura 2000, which are divided to 202

Special Areas of Conservation (SACs) and 241 areas as Habitats Directive requires Sites of Community Importance (SCIs). The total area protected from Natura 2000 is about 4,300,000 ha. In Greece forest ecosystems also contribute to protection of human resources from natural disasters, protection of erosion of soils, nutrient storage and recycling, pollution absorption, recreation for humans (e.g. hunting, environmental education, tourism possibilities), and service as carbon storage, improve of air, water reservoirs etc.

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

According to Dernegi (2010), Greece ranks third and fourth with 103 key biodiversity areas in Europe and Mediterranean area respectively. Genetic diversity is the fundamental basis of biodiversity at the species and ecosystems level according to Aravanopoulos (2011). Numerous studies in Greece show high levels of genetic diversity for *Castanea sativa* (Aravanopoulos et al., 2005); *Fagus sylvatica* (Magri et al., 2006); *Prunus avium* (Ganopoulos et al., 2011); *Pinus halepensis* (Fady-Welterlen, 2005). Greek forest populations present very high polymorphism and genetic differentiation according to a comparison with European forest which was conducted from Aravanopoulos et al. (2019).

While Greece harbors as it is mentioned a total protected area of about 4,300,000 ha for Natura 2000 network, there is a lack of protection of FGR in Greece. Greece has also participated in ICP Level II monitoring which regularly assess relationships between the state of forest ecosystems and anthropogenic as well as natural stress factors. In 1995, four plots were established; each one around 2.700m^2, one for *Quercus ilex* ecosystem, one for *Quercus fraineto*, one for *Fagus sylvatica* and one for *Abies borisii regis.* The Institute of Mediterranean Forest Ecosystems monitors since then each year those ecosystems and sends reports to the ICP Net.

In 1990, the first Ministerial Conference on the Protection of Forests in Europe adopted Strasbourg Resolution 2 on Conservation of Forest Genetic Resources. EUFORGEN (European Forest Genetic Resources Program) which was established in 1994 served as an instrument for the conservation of genetic diversity. Greece indeed was a part of the EUFORGEN program from 1994-1999, 2005-2014 and 2018-2020 (http://www.euforgen.org/member-countries/). In addition, Greece also joined EUFGIS (European Information System on Forest Genetic resources; http://www.eufgis.org/) project and established 15 Gene Conservation Units (GCUs) for *Pinus halepensis*, *Pinus brutia*, *Pinus nigra*, *Abies cephalonica* and *Abies borisii regis*. Seed stands that were chosen proved to harbor high levels of genetic variation for the five conifer species (Alizoti and Aravanopoulos, 2019). Furthermore, in Greece several species are in the limit of their natural distribution range (*Castanea sativa*, *Prunus avium, Picea abies*, *Pinus sylverstris* etc.). Considering the above aforementioned reasons of high biodiversity, genetic diversity and species refugia further measures have to be implemented in order to protect the high Greek genetic germplasm under the face of climatic changes.

1.4 What are the priorities and needs of your country to enhance these contributions?

Greece has to establish a national plan for FGR which will prioritize species that need *ex situ* and *in situ* conservation. National policies and regulatory frameworks are insufficient in Greece in order to protect enhance and improve FGR in Greece.

Some recommendations for protection and conservation of FGR include:

- A close collaboration with FAO and other global initiatives for collecting guidelines for conservation of FGR
- A stable funding from Ministry of Environment and Rural Development which will cover the partition of Greece in EUFORGEN for the next 20 years
- An information campaign which will inform citizens about the value of FGR
- A close collaboration between Forest Services, Universities and Forest Research Institutes for conservation and maintenance of the existing FGR and the establishment of new ones
- An emerge of the preparation of second National Forest Inventory (the First National Forest Inventory (NFI) was implemented in 1992).
- Establishment and strengthening of national FGR assessment, characterization and monitoring systems.
- Improvement of the institutional and policy framework in order to address the constraints related to the conservation, sustainable use and development of FGR.

- A need to harmonize measures for *in situ* and *ex situ* conservation, including through regional cooperation and networking

Part 2: State of diversity in forests and woodlands

2.1 State of forests and trends in their management

Greece increased the total forest area from 3,299 ha to 3,902 ha in the period 1990-2020 (FAO, Global Forest Resources Assessment main report 2020). In Greece public forests are being protected by a Constitutional Law of 1975 in articles 24 and 117. According to article 24 it is mentioned that "the protection of natural and cultural environment is an obligation of the State". As a consequence, public forest management is being implement by local authorities of public forest services in Greece. Currently, there are 7 General Directorates of Forests and Agricultural Affairs, 31 Forest Directorates and 80 Forest Services covering the total area of Greece. Sustainable forest management is being implemented in Greece in all public forest areas. The Forest services have the obligation to create and perform a 10-year management plan for each forest unit according to its peculiarities. The forest management plan is mainly a technical report focusing on sustainable timber yield without taking into account consideration the non-timber products and services of the forest resource (Zivojinovic et al., 2015). The main forest management approaches (Zivojinovic et al., 2015) for Greece include: wood production (including boat construction) and non-wood products (resin, honey, mushrooms, pharmaceutical/ medicinal plants).

According to Albanis et al. (2000), today in practice the basic rules that apply to every management plan is based to six criteria and indicators for the sustainable forest management:

1. maintenance and appropriate enhancement of forest resources and their contribution to global carbon cycles,
2. maintenance of forest ecosystem health and vitality,
3. maintenance and encouragement of productive functions of forests,

4. maintenance, conservation and appropriate enhancement of biological diversity of forest ecosystems,
5. maintenance, conservation and appropriate enhancement of protective functions in forest management (soil and water),
6. maintenance of other socioeconomic functions and conditions.

Although sustainable forest management is being implemented in Greece according to the criteria above, there is a serious limited number of forest engineers in the public forest services and together with bureaucratic procedures results to poor and unaffected forest management.

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

Forest management (FM) practices affect diversity on various levels: genetic, individual, population, species, and ecosystem (Kavaliauskas et al., 2018). Forest management may influence the genetic composition of stands directly through the selection of crop tree, different silvicultural systems, breeding, and seed transfer, and indirectly through changes in environmental conditions (Kavaliauskas et al., 2018). Furthermore, wood harvesting has a significant effect on the genetic diversity of forest tree populations, and numerous studies focus on the logging effects (thinning, selective logging) on genetic diversity and report contrary results. When clear cutting with standards or the seed-tree method is performed; removes most of the mature trees and only a few reproductively mature trees are maintained as a seed source. The consequence of this technique influences seed source and the next generation genetic diversity (Kavaliauskas et al., 2018).

The main obstacles for Greek forest management according to WWF 2011 are:

- Poor financing in forestry sector and lack of investment in state forest.
- Problematic logging system with significant deficiencies in the organization of wood harvesting in forests with significant negative effects both on forestry work and at the same forest ecosystem.

- Fractured and poorly performing system administration of forestry services. Forestry Services in two ministries (Ministry of Environment, Ministry of Interior), inappropriate governance structured Forest Service, external interference, dispersion and fragmentation of responsibilities of management responsibilities and protection forests, are some phenomena which render impossible the formulation of forest policy in the country and lead to ineffective management and inadequate protection.
- Incomplete support for forestry research, serious lag of regional forest services in the field of technology and absorbing new knowledge.
- Anachronistic context of forest management practices without usage of recent technology.

Forest fires

Furthermore, the forest sector and consequently FGR is seriously threatened in Greece from fires (Stougiannidou et al., 2020, Diakakis et al., 2016). The catastrophic fire in 2018 in Mati, near Athens resulted in the loss of 102 human lives, showing the ineffective management of fires in Greece. After this an International Committee was established with the supervision of Prof. Dr. Dr.h.c. mult. Johann Georg Goldammer, Director of Global Fire Monitoring Center and experts on forest fires. The report was deposited on January 2019 and presented the current situation for fires in Greece and recommendations for future management on forest fires (https://government.gov.gr/wp-content/uploads/2019/02/independent_committee compressed.pdf). Forest fires were always the most significant problem of Greek forests, especially in the last thirty years when their occurrence has risen rapidly (Xanthopoulos et al., 2012). The majority of fires take place in July and August followed by September and then June (Xanthopoulos and Nikolov, 2019).

In Greece, forest fires usually occur in areas with an altitude lower than 600m, in all the islands and in areas covered by pine trees and bushes. Factors such as urbanization, increased tourist activity etc. have contributed to the increase of this kind of disasters causing irreversible damage to the normal function of the ecosystems.

In 1960s, Greece suffered from a gradual abandonment of the countryside combined with a lack of management of forest ecosystems. This had the result of accumulating flammable wood materials as well as the significant increase in the number of forest fires and burned areas by the end of the 1970s. During the 80s and 90s this increase was exponential (Dimitrakopoulos et al., 2007). The Forest Land Registry was founded in 1976 according to articles 24 and 117 and in 1979 the law “on forest and potential forest areas protection” was voted, both measures to deal with this problem. Since the 80s, there has been an increase in forest fires and specifically in 1981, 1985, 1988, 1998, 2000 and 2007, the annual burned areas were over 1 million acres (Dimitrakopoulos et al., 2007).

In 1998 via a Ministerial decision, the responsibility for forest fires is passed from the forest service to the firefighting corps. This decision overlooked the complexity of the problem and focused the attention on the suppression efforts. Unfortunately, this exacerbated the problem. As a matter of fact, in the 1981-1997 periods, the average annual burned area was 46,462 hectares while in 1998-2014 it rose to 48,952 hectares, even though the firefighting corps was reinforced with forest fighting media (Xanthopoulos and Nikolov, 2019).

The phenomenon of forest fires in Greece displays some different characteristics compared to other countries globally, namely:

a. Existence of large forest and countryside fires.

b. Fires taking place in mixed zones (forest areas and inhabited areas).

c. Fire safety of archaeological areas and cultural heritage sites that are interconnected with the natural surroundings.

d. The incompletion of the national land registry and the non-existence maps of public and private forests and forest areas.

e. Incomplete fire safety plans for all the forest areas (either at a prefecture level or at forest complex level).

f. The non-existence of a formal and scientifically backed national system for evaluating the danger of fire commencements that will be based on the current environmental conditions.

g. The lack of a coherent fire safety plan.

h. Greece is the only country in Europe where the funds spent on suppression are disproportionally higher than those on prevention.

Forest fires are affected by climate change since the spread of the fire depends on the humidity of the burning material, which in turn is affected by rainfall, the relative humidity and the wind temperature and speed. In Greece, we have found a correlation between the factors affecting the chances of a forest fire and aridity. Years with higher aridity have shown a higher number of fires and burned areas. The danger of a fire starting is expected to increase in the future due to climate change that will bring along it extended periods of aridity and more heat waves. The increase of temperature will lead to an increase of fires and burned land while the time elapsed between two fires taking place in the same area will decrease. These will affect the southern continental part of the country and the island of Crete the most. The rise in burned area, suppression costs, damages and rehabilitation has been estimated that it will increase by 10 to 20% annually compared to today's figures.

Because of climate change, by 2100, the spatial distribution of forests will change. Forests of conifers and evergreen broadleaf trees will spread while forests comprised of fir, beech and pine trees will diminish. Therefore, tree species that are more flammable will prevail. The overarching goal is to cease forest fires, which are a big problem for both the state and the society. In order to accomplish that, one has to handle all the factors that are responsible for the rise in forest fires in the last decades. A combination of effectiveness and economic efficiency in the battle against forest fires can be formulated through a rational, holistic and balanced political approach (Xanthopoulos and Nikolov, 2019).

Insects

As Greece is situated in a crossroad between different countries and continents a lot of insect species have entered in the mainland and in many islands. A study from Avtzis et al. (2017) shows than 75% of the non-native entomofauna species in Greece originate from Asia, Australia, and North America. Avtzis et al. (2016) also showed that Greek pine processionary moths presented high similarity with Libyan haplotypes suggests a likely source population of the introduced individuals. Recently, in 2017 the first report of *Xylotrechus chinensis* (Coleoptera, Cerambycidae), which cause severe mortality in *Morus* species was reported (Leivadara et al., 2018). In 2019, a new insect *Tomicus piniperda* was presented in the urban forestry of Thessaloniki and destroyed 3.500 m^2 of it. It is apparent that insects will have a significant impact on health of forest in Greece due to the crossroad that the country belongs and due to the climatic pressures that face.

Pest and pathogens

Moreover, FGR in Greece are threatened by pest and pathogen infestations. In 1962 there was the first report of the fungus *Seridium cardinale* known as cypress cancer was detected in the island of Euboia (Anastassiadis, 1963). The pathogen destroyed a lot of natural cypress forests and as Xenopoulos and Diamandis (1985) pointed out no plantation will avoid infection in the near future in spite of the strict sanitation measures taken.

Moreover, Dutch elm disease caused by *Ophiostoma ulmi* was first reported in 1962 in Greece on *Ulmus minor* (*≡ U. campestris*), in Macedonia Region (Gibbs, 1981), then gradually spread all over the mainland and large islands were elms were occurring natural, or on plantations causing major losses. Till now, natural populations of *Ulmus minor, U. glabra, U. laevis* and *U. procera* are found under pressure by these pathogens in the country, while research efforts were directed all over Europe and in Greece on breeding for resistance (Diamandis and Perlerou, 2005). Interestingly *O. ulmi* is not currently found in a recent survey, seeing fully replaced in wild by more aggressive invaders *O. novo-ulmi* ssp. *novo-ulmi* and *O. novo-ulmi* ssp. *americana*, that is found overlapping and hybridizing in the country (Tziros et al., 2017).

Ceratocystis platani, an ascomycete fungus with possible origin in Central America, is the causing agent of canker stain disease of *Platanus* that is deadly to the highly susceptible native *Platanus orientalis* in Greece. It is progressing rapidly, killing large trees in 2-4 years after infection. There is no known cure for this disease. *C. platani* was first found in Peloponnese in 2003 (Tsopelas and Aggelopoulos, 2004) and up to present it has already caused the destruction of million trees of *Platanus orientalis* in natural stands, it is further spreading in the mainland and has the potential to cause the extinction of this iconic tree species from the country, in track with the impact of Dutch elm disease in country's natural populations of elms (Tsopelas et al., 2017b).

Cryphonectria parasitica, an ascomycete fungus originating from East Asia and the causal agent of chestnut blight, was first recorded in 1963 in Pelio region, central Greece (Biris, 1964). It quickly spread all over the country causing damage in natural stands of *Castanea sativa*.

Seiridium cardinale the causal agent of cypress canker and a well-known invasive ascomycete destroying Cupressaceae around the Mediterranean basin (Graniti, 1998) was first observed in 1962 in Euboea, central Greece. It is already established all over the mainland and the islands, while the pathogen spread has been accelerated by the mass use of the highly susceptible Leyland cypress as a windbreak, during the past decades. The spread of the pathogen is favoured on wet and warm valleys, like some regions of central-western Peloponnese or Euboea, where it has caused a mass loss of landscape cypress trees. *Cupressus sempervirens* and *Cupressus macrocarpa*, as well as many *Juniperus* native on Greece, are affected by this pathogen. The European Research effort on screening/breeding for resistance has provided partly some solution (Xenopoulos, 1990). Currently, there is no known cure for this disease and infected trees must be removed, this is not feasible in natural stands, thus high inoculum is contained.

Phomopsis juniperivora was found in 2014, on the island of Paros, Cyclades, in coastal sand dunes causing branch dieback in natural growing shrubs of *Juniperus macrocarpa* (Tsopelas et al., 2017a). In pathogenicity inoculation tests with *Phomopsis juniperivora* on plants of *J. macrocarpa*, *J. oxycedrus* and *Cupressus macrocarpa* dieback symptoms were observed. This fungus, a significant pathogen of *Juniperus* in North America, is an alien invasive pathogen in

Greece, posing the risk to further degrade populations of junipers and other Cupressaceae naturally occurring all over the country in priority habitat types.

The fungi-like genus *Phytophthora* (Oomycota) is prominent in new emerging plant diseases worldwide, consisting mostly of important soil-plant pathogen species, with new reports and records in rising numbers and new hosts every year; a trend that keeps in track with increase in trade of plants for planting. *Phytophthora cambivora*, *P. citricola* and *P. cryptogea* have been reported as pathogens causing ink disease in *Castanea sativa* orchards in Greece (Vettraino et al., 2005). The highly destructive *P. nicotianae*, known to infect more than 250 plant hosts worldwide, was reported in genus *Platanu*s as a new host for the first time in urban plantations of *Platanus* trees in Greece (Tsopelas et al., 2018b). Established *Phytophthora* species along with newly invaded are known to be able of interspecific hybridization increasing the chance of giving rise to entirely new organisms, or to genetically modified pathogens exhibiting new host ranges (Brasier et al., 2004), posing a serious risk on native forest ecosystems of Greece.

Dothistroma septosporum, an ascomycete that probably originate from north-east Europe (Adamson et al., 2018), has invaded pine forests worldwide and is one of the causal agents of Dothistroma needle blight (DNB). *D. septosporum* has been known in Greece since the early 1980s, recorded in Lagada, northern Greece. In a survey contacted in this area in 2011 (Tsopelas et al., 2013) DNB infection seemed to be limited to a valley in this area in *Pinus nigra* and *P. brutia* plantations established more than 50 years ago. The foliar damage caused by this fungus affects the growth rate of infected plants. DNB does not appear to be very common in Greece, although intensive monitoring of the spread of this pathogen is currently lacking.

Neofusicoccum parvum is an ascomycete, belonging in Botryosphaeriaceae that is causing branch and shot dieback due to canker development in a wide range of susceptible hosts. It has been reported at least from 90 hosts in 29 countries on six continents(Sakalidis et al., 2013). In Greece, it has already been reported causing dieback in natural occurring *Salix alba* and in plantations of *Sequoiadendron giganteum* (Tsopelas et al., 2018c).

Diplodia corticola is an ascomycete that is causing branch and shot dieback in oaks (*Quercus*) and having already invaded several countries of Mediterranean basin. In 2007, it was first observed in SW Peloponnese, Greece causing extensive branch and shoot dieback on Kermes Oak (*Quercus coccifera*) shrubs and trees (Tsopelas and Aggelopoulos, 2018, Tsopelas et al., 2018a). This was the first record of *D. corticola* in Greece and *Q. coccifera* is a new host of the fungus in Europe. Since its first report, this pathogen has spread further north in the mainland of Greece, causing severe dieback of susceptible *Q. coccifera* and *Q. ilex* both in natural ecosystems and urban plantations.

Other threats

FGR also face a direct threat from climatic changes in Greece due to the fact that stressed trees are more susceptible to insect pests and diseases. Moreover, significant impacts from drought season (Tigkas, 2008), climate change where significant impacts will occur in biodiversity levels at all levels of diversity including genetic diversity (Kougioumoutzis et al., 2020, Vogiatzakis et al., 2016). Moreover, growing demand for land for the production of agricultural commodities has resulted in sometimes irreversible changes to forest cover (Minetos and Polyzos, 2010, Gounaridis et al., 2014). Introduction of invasive alien species also (Dimitrakopoulos et al., 2017) are also evident in Natura 2000 Special Areas of Conservation (SAC), and the biodiversity will significantly be impacted. Moreover, overgrazing and illegal cuttings further affect biodiversity fur to the fact that animals consume the natural regeneration and illegal cutting remove the mature trees from the forest ecosystems.

Overall FGR in Greece are seriously affected from forest management practices, from human interventions and from biotic and abiotic factors which are triggered by economic crisis and climatic changes.

2.3 Challenges and opportunities for forest genetic resources

Genetic variation is the essential and the fundamental basis for the adaptation and resilience of tree species to environmental stress and change. Under the face of climatic changes, human pressures and biotic and biotic factors, ensuring future food security and environmental sustainability is more important than ever. Management of FGR must be a key stone step in order to meet the growing demand for forest services. While sustainable forest management is being implemented in Greece, it is an obligation derived by the Constitution, FGR conservation and management need to be integrated in the forest management plans.

Challenges are evident in the Greece's:

- land use through the existing land clearing, deforestation, and illegal logging
- insufficient capacity and funding and resources for training survey, identification management and monitoring
- lack of public and political awareness for conservation of FGR
- lack of coordination among policies, laws, government departments for FGR

Opportunities which can be raised include:

- development of renewable energy sources (eg through energy plantations)
- improvement of natural resource management and forest restoration
- involvement of private sector in "in situ" and FGR reserve systems
- education and communication campaigns for general public and stakeholders
- revision of existed policy and legislation in order to protect and conserve FGR

Chapter 3. State of other wooded lands

3.1 State of other wooded lands and trends in their management

Numerous wood trees are cultivated in Greece, according to the Ministry of Agriculture report 2018 (accessible through http://www.minagric.gr/index.php/el/pinakas-3-dendrodeis-monimes-kalliergeies/file/). The total area covered for fruits cultivation for different woods is 1.159.301 ha and total production is 4690761.2tn. These areas are private managed and cultivated and ELGO –DIMITRA which is a Research Organization under the umbrella of Ministry of Rural Development and Food provides scientific guidance. ELGO DIMITRA consists of multiple research organizations and its primary target is to scientifically consult and provide information for appropriate cultural management practices and for treatment of pests, insects and pathogens. Recently ELGO-DIMITRA and more specifically Institute of Olive Tree, Subtropical Crops & Viticulture, under the supervision of Dr. Georgios Koubouris characterized 10 cultivars after 10 years of experimental procedures. Ten significant cultivars accessions, eight from Greece (Amfissis, Chodrolia, Chalkidiki, Koroneiki, Koutsourelia, Lianolia of Corfu, Megaritiki, Stroggilolia and Tsounati) and two from Spain (Arbequine και Picual) have now, their characterized mother trees and can distributed to farmers in order to cultivate certificated cultivars. Moreover, the Institute of Plant Breeding and Genetic Resources (IPBGR) is continuously working for genetic improvement of various tree cultivars such as figs, oranges, cherries, apples etc. There are plenty published papers that contain information about breeding programs for important tree cultivars (Ganopoulos et al., 2018a, Ganopoulos et al., 2018b) and for other agronomical important plants (Tsaballa et al., 2020) .

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

Due to the fact that climatic changes affect also agricultural and other wooded lands (such as plantations) there is an emerge for protection of FGR. It is expected that in future years there will be more afforested areas in order to increase food protection. Under this scenario it is important to secure FGR conservation and protection for sustainability in future years.

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

According to the Second Report on the states of the world's plant genetic resources for food and agriculture published from FAO 2010, it is pointed out the emergence to secure broad diversity of crop plants, including their wild relatives and underutilized species, in accessible conservation systems, and to increase capacities for plant breeding and seed delivery worldwide in order to tackle the challenges of climate change and food insecurity. A future usage of wild trees and their association with cultivated trees in Greece is a fundamental basis in order to accomplish breeding programs under the climatic changes scenario.

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

Fast growing forest tree species are globally used as a source for covering the globally increase of paper and wood-fibre panels (Cossalter & Smith 2003). According to Aravanopoulos (2010), the most important fast growing forest tree species in Greece are poplars, willows, plane trees, the naturalized black locust and exotic eucalypt species poplars, willows, plane trees, the naturalized black locust and eucalyptus species. In Greece there were breeding programs for plantation of forest growing species which are initiated 1970 and were continued until 2000. Most of those plantations were for *Populus* species (161.000 ha) and for *Platanus* species (9.000ha) for Greece (Aravanopoulos, 2010). From a Msc thesis conducted by Ermioni Malliarou (2014) five hybrid clones of *Platanus* and seven of *Populus*, resulting from a fast-growing species genetic improvement program of the Forest Genetics and Tree Breeding Laboratory, Aristotle University of Thessaloniki (1975 – 2010), were investigated.

Furthermore, under the European program FRAXIGEN (EVK2-CT-2001-00180), seed were collected from eight natural populations of *Fraxinus angustifolia* and further used for establishment of plantations. The plantations were evaluated after ten years and the *F. angustifolia* trees presented comparable values regarding biomass production (Spanos et al., 2018).

Moreover, agroforestry systems are a traditional land use practice in Greece. They are widely distributed all over the country and constitute important elements of the rural landscape. They include all three types of systems: silvoarable involving trees and crops grown on arable land, silvopastoral involving trees and pasture/animals grown on forest and arable land and agrosilvopastoral involving trees, crops and grazing animals grown on arable land. Trees may be forest species or cultivated trees grown for fruits, naturally regenerating or planted, evergreen or deciduous; crops may be annual or perennial species; and animals may be sheep, goats, cattle, pigs or chicken (Papanastasis et al., 2009). Table 1 shows the prominent agroforestry systems based on the dominant tree. It must be noted that although all these systems form pure stands, in several of them the dominant tree species is grown together with other tree species as well resulting in mixed agroforestry systems.

Table 1. Prominent agroforestry systems of Greece classified according to the dominant tree species (systems with bold numbers are described in detail in the text) (adopted from Papanastasis et al. 2009).

Dominant tree species	Main understory species	Region	Main products/ uses
1 Natural coniferous			
1.1 ***Abies cephalonica***	Herbaceous	Central Greece, Peloponnesus	Timber, forage
1.2 ***Abies borisii-regis***	Herbaceous	Pindus mountain range	Timber, forage

1.3 *Pinus halepensis*	Evergreen shrubs	Attica, Euboea, Kassandra	Resin, fuelwood, timber, forage, honey
1.4 *Pinus brutia*	Evergreen shrubs	Crete, Thassos, Dadia, Aegean islands	Timber, fuelwood, honey, forage, resin
1.5 *Pinus nigra*	Herbaceous	Pindus mountain range	Timber, electricity poles, forage
1.6 *Pinus leucodermis*	Herbaceous	Pindus mountain range	Timber, barrel wood, forage
1.7 *Pinus pinea*	Herbaceous, evergreen shrubs	Peloponnesus	Forage, timber, pine nuts
1.8 *Pinus silvestris*	Herbaceous	Macedonia, Thrace	Timber, electricity poles, forage
1.9 *Cupressus semprevirens*	Evergreen shrubs	Crete, Aegean islands	Forage, timber
2 Natural broadleaved evergreen			
2.1 *Quercus coccifera*	Evergreen shrubs, phrygana	Crete	Forage, acorns, fuelwood
2.2 *Quercus ilex*	Evergreen shrubs	Western Greece	Charcoal, fuelwood, forage
3 Natural broadleaved deciduous			
3.1 *Quercus ithaburensis ssp. macrolepis*	Phrygana, herbaceous, arable crops	Western Greece, mainland, Aegean islands	Forage, fuelwood, acorns, cereals
3.2 *Quercus trojana*	Herbaceous, deciduous shrubs, arable crops	Western Macedonia, Thrace, Thessaly	Fuelwood, cereals, forage, timber, fodder, acorns
3.3 *Quercus pubescens*	Herbaceous, deciduous shrubs, arable crops	Various places in mainland	Timber, fuelwood, fodder, cereals, forage, acorns

3.4 *Quercus frainetto*	Herbaceous, deciduous shrubs, arable crops	Various places in mainland	Timber, fuelwood, fodder, cereals, forage, acorns
3.5 *Quercus petraea*	Herbaceous, deciduous shrubs, arable crops	Thessaly, Macedonia	Timber, fuelwood, fodder, cereals, forage, acorns
3.6 *Quercus cerris*	Herbaceous, deciduous shrubs, arable crops	Thessaly, Western Macedonia, Thrace	Fuelwood, forage, cereals, fodder, acorns
3.7 *Castanea sativa*	Herbaceous, deciduous shrubs, arable crops	Various places in mainland	Poles, fuelwood, fruits, fodder, honey, mold
3.8 *Fagus silvatica*	Herbaceous, potato crops	Northern Greece	Timber, forage, potatoes
3.*9 Pyrus amygdaliformis*	Herbaceous, deciduoud shrubs, arable crops	Various places in mainland	Forage, fuelwood, cereals, fruits
3.10 *Acer campestre*	Herbaceous, deciduoud shrubs	Eripus, Central and Northern Greece	Fuelwood, forage
3.11 *Celtis australis*	Herbaceous, arable crops	Northern Greece	Fuelwood, forage, timber, fruits
4 Cultivated conifers			
4.1 *Cupressus semprevirens*	Arable crops, herbaceous	In various plains	Windbreaks, agricultural products, timber
5 Cultivated broadleaved evergreen			
5.1 *Olea europea*	Arable crops, herbaceous	Mainland and islands	Olives, forage, fodder, cereals, grapes, fuelwood, wood

5.2 *Ceratonia siliqua*	Herbaceous, arable crops	Crete, Peloponnesus, Aegean islands	Fruits, forage, cereals, grapes, fuelwood
6. Cultivated Broadleaved deciduous			
6.1 *Populus thevestina*	Arable crops	Macedonia, Thrace	Timber, vegetables
6.*2 Populus (clones)*	Herbaceous, arable crops	Macedonia, Thrace, Thessaly	Timber, vegetables, forage
6.3 *Juglans regia*	Arable crops, herbaceous	Various places	Timber, nuts, cereals, grapes, forage
6.4 *Prunus amygdalus*	Arable crops, herbaceous	Mainland and islands	Almonds, grapes, cereals, fuelwood, forage
6.5 *Ficus carica*	Arable crops, phrygana	Mainland and islands	Fruits, grapes, cereals, forage
6.6 *Robinia pseudoacacia*	Arable crops, herbaceous	Various places in mainland	Timber, honey, fodder, forage
6.7 *Morus alba*	Arable crops, herbaceous	Evros, Chalkidiki, Thessaloniki, Crete	Foliage (for silkworms), fodder, duelwood, cereals, forage, fruits
6.8 *Castanea sativa*	Herbaceous	Various places in mainland	Timber, fruits, forage
6.9 *Prunus avium*	Arable crops	Various places in mainland	Fruits, cereals, vegetables, grapes, forage, fuelwood
6.10 *Malus communis*	Arable crops	Various places in mainland	Fruits, cereals, vegetables, grapes, forage, fuelwood
6.11 *Pyrus communis*	Arable crops	Various places in mainland	Fruits, cereals, vegetables, grapes, forage, fuelwood

6.12 *Prunus persica*	Arable crops	Central and Northern Greece	Fruits, cereals, vegetables, grapes, forage, fuelwood
6.13 *Prunus armenica*	Arable crops	Various places in mainland	Fruits, cereals, vegetables, grapes, forage, fuelwood
6.14 *Prunus domestica*	Arable crops	Various places in mainland	Fruits, cereals, vegetables, grapes, forage, fuelwood
6.15 *Cydonia oblonga*	Arable crops	Various places in mainland	Fruits, cereals, vegetables, grapes, forage, fuelwood

There is no information concerning the exact area covered by agroforestry systems in Greece. Interestingly, there is no designation for such land use officially. Therefore, we had to use indirect statistical data and even guesswork in order to arrive at some numbers.

For the agroforestry systems on forest land researchers used an official inventory of the Forest Service for various forest types (National Forest Inventory, Ministry of Agriculture 1992). As agroforestry systems all open forests (less than 100 m^3/ha of timber stock) and trees with measurable DBH, i.e.>5 cm are considered. It is assumed that such forests have a crown canopy cover less than 40% and may support an undergrowth with herbaceous or woody vegetation that provides forage to livestock, making grazing management their primary objective (Papanastasis and Etienne, 1996). Such systems amount to 1.079,611 ha or 32% of the total area of the industrial (high) forests (Table 1). As this figure does not include grazable forest, it appears to be only a conservative estimation.

The exact area of grazing forests in Greece is not officially known but we can deduce by taking into account that most forests are grazing areas- that agroforestry systems on forest land amount to more than 2 million hectares. The kind of forests used for grazing include the so called Mediterranean forests, i.e. Aleppo pine (*Pinus halepensis* Mill.) and Brutia pine (*P. brutia* Ten.), most of the mountainous pine forests [Austrian pine (*P. nigra* Arn) Scots pine (*P. Sylvestris* L.) and

Heildrich pine (*P. leukodermis* Ant)] and the deciduous oak forests, especially the ones with a coppice form (Papanastasis, 1986).

The National Statistical Service of Greece (2005) provided data concerning agroforestry systems on agricultural land. Based on these, researchers have come to the assumption that agricultural systems existing in the whole agricultural area of Greece, amount to 3,483.200 ha, apart from the areas where land consolidation or reclamation was applied followed by irrigation; this resulted in the removal of almost all the naturally grown trees. If the irrigated areas together with the pure tree plantation area (monocultures) are subtracted from the total cultural area, we are presented with a figure of 1,044.875 ha representing 30% of the whole agricultural area (Table 2). This area includes agroforestry systems with trees both naturally occurring and cultivated. The area corresponding to cultivated trees (monocultures), according to the National Stat. Service (2005), is shown in Table 3. Such systems represent 19% of the total area of agroforestry system on agricultural land. It must be noted however, that this figure represents a conservative estimate based on our assumption that the trees are planted in the same densities as the ones in pure plantation-which may not be true. Anyhow, it stands as the closest estimation researchers can get using the inadequate available data (Papanastasis et al. 2009).

Table 2. Area (in ha) covered by agroforestry systems on forest land (from Papanastasis et al. 2009)

Forest type	Timber stock	Area with measurable trees (DBH ≥ 5 cm)	Area without measurable trees (DBH < 5 cm)	Estimated area of agroforestry systems
Industrial	0c	57,359	505,988	57,359
	1–100	1,022,252	1,283,358	1,022,252
	>100	404,876	85,353	–
Non-industrial	0	–	3,153,882	–
Total		1,484,487	5,028,582	1,079,611

Table 3. Area (in ha) covered by agroforestry systems on agricultural land[a] (from Papanastasis et al. 2009).

Group of tree	Individual species	Estimated
Natural	Oaks, wild pears and other forest	843,700
Cultivated		
Citrus trees	Orange, lemon, mandarin, etc.	6,498
Fruit trees	Apple, pear, peach, apricot,	17,770
Nut and dried fruit	Almond, walnut, chestnut, carob,	41,352
Olive trees	Both for edible olives and olive oil	124,311
Other trees	Plum, mastic, poplars, cypress,	11,244
Total		1,044,875

Description of the Most Important Agroforestry Systems

Greece has still a great variety of traditional agroforestry systems but not all of them are equally important considering the area covered. In this section, there are descriptions of the most common/widespread systems based on the classification proposed in the previous section presented in Table 2.

Aleppo Pine Forests

Aleppo pine (*Pinus halepensis*) is one of the most important forestry trees, a native coniferous species thriving in almost all bioclimates in the Mediterranean region. In Greece, it is found in several parts of the mainland and on the Ionian islands, being also one of the main species for reforestation purposes. As it is a light-demanding tree, pine forests have open crowns allowing the flourishing of rich understory usually consisting of evergreen shrubs and among them several herbaceous species. This rich understory often results in the accumulation of very flammable biomass (Liacos, 1986). That is the reason behind the fact that pine forests are the most commonly burnt forest areas in Greece. It exerts a strong competition to the overstory for water and nutrients (Liacos, 1986, Papanastasis, 1986) although the species is heat and drought tolerant, its Biogenic Emissions considered to be very low. Aleppo pine forests have multiple uses. The trees can be either for timber or for fuelwood, also for resin and honey. Resin can be used for glue and as a flavour additive to the popular Greek wine, known as "retsina". Bees fed on honeydew secretions of the insect Marchalina hellenica endemic in the Greek Aleppo pine forests, produce honey having a distinctive aroma (Schultz et al., 1987). Understory vegetation is used for fuelwood but mainly for grazing by livestock. Although this vegetation is not usually of high feeding value, it becomes indispensable in the absence of better quality feed-mostly in the case of goats (Papanastasis, 2001). For this reason, Aleppo pine forests have been traditionally used as silvopastoral systems. Livestock-esp.goats- grazing can control the understory vegetation to the benefit of the trees ((Liacos, 1980, Liacos, 1986, Papanastasis, 2001, Papanastasis et al., 2009, Papanastasis, 1986).

Brutia pine forests

Brutia pine (Pinus brutia) is also a warm Mediterranean coniferous species distributed mostly in the eastern part of the Greek mainland, the Aegean islands and in Crete. Well-known for its ornamental quality, it is extensively used in artificial plantations, mainly in Northern Greece. A light - demanding species as well, its natural stands are open, supporting lush understory vegetation composed of various herbaceous and/or shrubby species (Liacos 1986). Therefore, Brutia pine forests are really vulnerable to wildfires (Liacos 1986). The density of the overstory affects directly the amount of the understory biomass as well as the species composition. An experiment involving three spacings of an artificial Brutia pine plantation in northern Greece, proved that the amount of herbaceous understory and the tree diameter increased proportionately to the trees' spacing (Platis et al., 1999, Mantzanas et al., 2005). Moreover, the tree canopy helped to maintain an average understory herbaceous biomass of 1,764 Kg ha in August- almost as high as in May (1,713 Kg ha). This suggests that Brutia pine silvopastoral systems can extend the grazing period of livestock well into summer while otherwise, herbaceous species get dormant without the protective tree canopy (Mantzanas and Papanastasis, 2003). Brutia pine forests belong to multiple use forest systems. Their timber is more qualitative than that of Aleppo's, but resin production is substantially less. Brutia pine forests are traditional silvopastoral systems with livestock grazing, mainly goats, contributing to the control of understory vegetation and consequently to the reduction of fire risks (Tsiouvaras 2000) We must also mention that it helps maintain biodiversity including birds of prey, as it is the case of Dadia forest (Bakaloudis et al., 1998, Papanastasis et al., 2009).

Cypress Systems

Cypress (*Cupressus sempervirens* L.) is found in the southern Aegean islands and in Crete where it forms natural forests either alone or together with Brutia pine. It was introduced throughout Greece in both the eu- and the sub-Mediterranean zones, creating open forests. The rich understory vegetation of various phryganic and herbaceous species, vulnerable to wildfires although cypress itself is less flammable than Brutia pine. Natural forests of cypress are limited in distribution and size. They can be used for timber production and especially for grazing, so they can be considered as important silvopastoral systems. Artificial cypress forests have of course the same use, with cypress trees planted in pine plantation's borders in narrow strips for protection against wildfires. Another common use of the cypress tree is ornamental, so nowadays Cypress trees can be found along national roads, in urban parks, around churches and cemeteries. Additionally, Cypress trees are planted in agronomic lands to mark borders or as a windbreak. These uses result in successful silvoarable or agrosilvopastoral systems (Papanastasis et al. 2009).

Kermes Oak Systems

Kermes Oak (*Quercus coccifera* L.) is an evergreen broadleaved tree species grown in the eu-Mediterranean and sub-Mediterranean zones in Greece. Well known since antiquity, Kermes Oak is the food-plant of the Kermes scale insect which provided a red dye called crimson. Because of its repeated cutting, burning and browsing it is commonly found as a shrub forming extensive communities (dwarf vegetation) pure or mixed with other evergreen or deciduous shrubs known as "prinones" (Kermes oak shrublands). Prinones are mainly used for grazing. Kermes oak trees, on the contrary, are only found in protected areas (urban, sub-urban forests, around churches, cemeteries, private farms), either isolated or in small thickets. In certain parts of the mainland and in islands-especially in Crete, we can find substantial areas of Kermes oak trees forming silvopastoral systems known as "prinodhasi" (Kermes oak forests), withstanding heavy grazing. Other tree species may co- exist with Kermes oak. Representative silvopastoral systems are found in Crete, growing usually in limestone areas providing a mixed understory with woody and herbaceous species. In such a system found on Psilorites mountain of Crete (Mountain Ida) the understory vegetation was composed of herbs (37 g/m^2) and shrubs (13g /m^2) while the acorn yield was 21g /m^2. Flocks of sheep/goats consumed 73%, 29% and 89% of these yields respectively by the end of the grazing period in June (Papanastasis and Misbah, 1998, Papanastasis et al., 2009).

Valonia Oak Systems

Valonia oak [*Quercus ithaburensis* Decaisne ssp. Macrolepis (Kotschy) Hedge & Yalt] is a deciduous species grown in several parts of the Greek mainland and on various islands having eu- or sub-Mediterranean climate, covering an area of approx. 30.000 ha. Its natural stands are relatively small and mostly pure, rarely intermixed with other deciduous oak species [pubescent oak (*Q. pubescens* Will.) or Italian oak (*Q. frainetto* Ten.)]. The understory provided by the Valonia oak species is both woody and herbaceous (Papanastasis, 2002, Platis, 2002)Pantera and Papanastasis 2001). Its canopy density amounts to 20-50 trees per hectare and its cover rarely exceeds the 40% of the ground (Schultz et al. 1987). This means that Valonia oak forests are open, a beneficial factor for understory vegetation, suitable for grazing. This kind of oaks are also found in the borders of cultivated fields-usually with cereals, being a part of silvoarable systems or agrosilvopastoral if browsing occurs after the harvest of the crops. Fuelwood production is another important element, as there is significant amount per tree cut and the demand is currently growing. Last but not least, the use of its acorn cups should be mentioned, playing an important role in the extraction of tannins used in the leather industry (Papanastasis et al. 2009).

Macedonian Oak Systems

Macedonian Oak (*Quercus Trojana* Webb.) is a late-deciduous/ semi-evergreen oak tree, found in several parts of the Greek mainland, particularly in western Macedonia where it creates extensive forests either pure or mixed with other oak species such as pubescent, Italian, sessile [*Q. petraea* (Matt) Liebl] and Turkish (*Q. cerris* L). Most natural stands are open, supporting lush understory vegetation woody or herbaceous (Grove and Rackham, 2003). Woody species belong to other oak species (pubescent, Turkish, Italian) in shrubby form together with other shrub species [oriental hornbeam (*Carpinus orientalis* Mill.), manna ash (*Fraxinus ornus* L.). This abundant undergrowth results in the use of Macedonian Oak forests as a successful silvopastoral system for sheep and goat, as they feed not only on the understory vegetation, but also on the fallen leaves and acorns. Macedonian oak trees are also used for fuelwood when they are old enough and yield large amount per tree cut. The demand for this kind of wood is getting higher nowadays. Macedonian oak is also found in silvoarable/agrosilvopastoral systems with arable crops, particularly cereals. In these systems, Macedonian oaks are grown within or in the boundaries of the arable fields (Papanastasis et al. 2009).

Other Deciduous Oak Systems

Other species of deciduous oaks are common in Greece, covering almost 1.5 million hectares (Ministry of Agriculture 1992). They include pubescent, Italian sessile and Turkish oaks, all of them creating either high or brushwood forests. They are primarily used for timber or fuelwood. Although most of the forests -especially the coppice- are grazed by livestock, they cannot be considered as silvopastoral systems due to their density which allows limited understory vegetation or the risk of their regeneration being damaged (by the browsing animals). All these oak species form quite extensive silvoarable or agrosilvopastoral systems especially on mountainous areas. They provide fuelwood and are suitable for feed production (by pulverizing or pruning), give shade to livestock in the summer midday heat and may serve as markers of property boundaries in case of arable fields. These fields are mostly used for cereal crop, but also for barley (*Hordeum vulgare* L.) or wheat (*Triticum aestivum* L.) making suitable pastures during winter/ early spring (Papanastasis et al. 2009).

Olive Tree System

The Olive tree is one of the most commonly cultivated trees in the eu-Mediterranean zone of Greece. Its origins are antediluvian-everybody knows the olive branch brought to Noah by the dove, and fossil evidence proves its presence in the Oligocene Period. It is grown in pure orchards and often with other species. Olive orchards are mostly kept free from understory vegetation in order to enhance olive production. However, sometimes various crops may be planted in the understory such as vines or cereals, resulting in a typical silvoarable system. In several cases, pasture may be established under the olive trees or else spontaneous vegetation is grown used for grazing by livestock, presenting typical silvopastoral systems. Another more complex system may also be formed, such as the agropastoral one, when olive groves are grazed after the harvest of the crop, in the case of olive trees/cereal combination. It is a well-known fact that olive trees are mainly grown for the production of their olives, but we should also state that the pruned branches are also used as woodfuel or for animal feed (in situ or in the barn) (Papanastasis et al. 2009).

Poplar Systems

Poplar (*Populus* spp) is a deciduous flowering plant having a large genetic diversity (with more than 30 species), native or naturilized in Greece, but occupies relatively limited area. On the other hand, artificial plantations with Lombardy poplar (*P. thevestina* Dode) and clones of hybrids between native and American species cover a much larger area, contributing to timber production in Greece. Poplars are grown/planted in cultivable lands with good soils, irrigated or with suitable water conditions (i.e. water canals or riverbanks) Their understory vegetation is adequate due to their open stand, and can be used for grazing, appearing as special silvopastoral systems (Schultz et al.,1987). A common pattern lately, is the appearance of Lombardy poplar or hybrids along watercourses or around arable fields cultivated with vegetables or other summer crops. This pattern allows us to name the poplar system as a typical silvoarable, traditionally found in several parts of Greece, most commonly in the northern parts of the country. Poplars are known to be common utility hardwoods and are used for timber production but can also serve other purposes, namely boundary marking or wind breaking (Papanastasis et al. 2009).

Walnut Tree Systems

Walnut trees belong to the genus *Juglans* (family Juglandaceae) with *Juglans regia* and *Juglans nigra* being more common. It is commonly cultivated in the sub-Mediterranean and mountainous zones of Greece. The tree is planted in arable lands either in pure orchards or within plowable fields alone or with other trees. It can be combined with several crops, especially vines and cereals. In the case of vines, it makes a typical silvoarable system, while with cereals; it presents a typical agrosilvopastoral system when flocks graze after the harvest of the cereals. However, it is rarely used for the creation of pure silvopastoral systems. Walnut trees produce is their nuts and of course, timber of high quality mostly used for furniture.

Typical silvoarable systems combining walnut trees and vineyards, cereals, lucerne, vegetables or dry beans have been recorded in the municipality of Askio, western Macedonia in northern Greece (Mantzanas et al., 2005, Papanastasis et al., 2009).

Almond Tree System

Almond tree (*Prunus amygdalus* Batsch) is the well-known tree " bringing" the message of spring with its flowers appearing before its leaves in early spring. Almond is also the name of the edible and widely cultivated seed of this tree. Thriving in the eu-Mediterranean and sub-Mediterranean zones of Greece, it can be found particularly in dry areas of the mainland and on the islands. Planted alone or with other trees such as olives, fig trees, walnuts and pistachios, it creates pure orchards or is combined with vines or herbaceous crops. However, it is mostly free of any understory vegetation, due to frequent cultivation or use of herbicides. Joint cultivation with other crops can be common, resulting in a typical silvoarable system. Herbaceous crops may include cereals, tobacco, forages and legumes. If grazed after harvest, we have an agrosilvopastoral system, while pure silvopastoral systems are rarely found. Typical silvoarable systems combining almond trees and cereals (barley/ wheat) are found in the Municipality of Askio (western Macedonia, northern Greece) (Mantzanas et al., 2005), and on some Aegean islands where silvoarable systems are more extensive.

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

5.1 State of genetic diversity in trees and other wooded plant species in the country

In the last 20 years and after the exploitation of molecular markers numerous studies have been implemented in Greece concerning forest genetic diversity parameters of important forest trees.

In a tree breeding program that was established by laboratory of Forest Genetics and Tree Breeding of AUTH, 36 selected plus trees of *Prunus avium* L. genotypes from four different locations were assessed and genotyped with SSR molecular markers (Avramidou et al., 2010).

Later on Ganopoulos et al. (2011) studied five natural *Prunus avium* populations from northern Greece based on 46 ISSR and 11 SSR loci. Populations presented a relatively high level of genetic variation and exhibited a dynamic pattern of maintaining extant genetic variability and evolutionary potential. The studied populations, located at the rear edge of the species European distribution, reveal a wealth of genetic variation that is essential for population survival under the climatic change scenarios.

Under the program LIFEGENMON, (LIFE13 ENV/SI/000148) which was funded on March 2014 with Slovenian Forestry Institute as a coordinator and with partner the Laboratory of Forest Genetics and Tree Breeding of Department of Forestry & Natural environment from AUTH a forest genetic monitoring program is being implemented under the supervision of Prof. Filippos Aravanopoulos. The team of AUTH established two plots; one for *Fagus sylvatica* and one for *Abies borisii-regis*. By using molecular markers such as microsatellite repeats and single nucleotide polymorphisms they studied the genetic variation through time by assessing indicators for forest genetic monitoring (Aravanopoulos, 2011, Konnert et al., 2011). Preliminary results showed that genetic variation is stable through years. More information can be assessed through web page: http://www.lifegenmon.si/.

Under the H2020 funding, a program called GENTREE: "Optimizing the management and sustainable use of forest genetic resources in Europe" was implemented from 1st March 2016 – 28 February 2020 and Prof. Filippos Aravanopoulos from the Laboratory of Forest Genetics and Tree Breeding of Department of Forestry & Natural environment from AUTH was a partner of the consortium. Under this project several species were sampled along Greece: *Fagus sylvatica, Picea abies, Pinus sylvestris, Populus nigra, Abies alba, Pinus halepensis, Pinus nigra, Taxus baccata* and genotyped in order to tackle phenotypic and genetic variability and to be associated from other European countries in order to present future conservation actions,

From a recently co-financed program by Greece and the European Union (European Social Fund-ESF) through the Operational Program «Human Resources Development, Education and Lifelong Learning 2014-2020» a project was funded entitled: "Genetics, epigenetics and metabolomic analysis of European yew (*Taxus baccata*) in order to select plant material for the production of taxol and other antineoplastic taxanes in Greece" (MIS 5004922). The project was implemented in the Laboratory of Forest Genetics and Tree Breeding, Department of Forestry and Natural

Environment, AUTH University under the supervision of Prof. Filippos Aravanopoulos. The aim of the study was the investigation and identification of metabolomic profile, genetic and epigenetic variation between and within three peripheral Greek populations (Mt Cholomon, Mt Olympus and Mt Vourinos). The analysis revealed significant levels of chemodiversity within and among the investigated populations and significant seasonal variation that could be exploited for the selection of superior germplasm native to Greece, for yew plantations and further exploitation which is necessary for the production of important taxanes (Dalmaris et al., 2020).

Furthermore, Papageorgiou et al. (2005) studied genetic differences between autochthonous and breeding populations of common cypress (*Cupressus sempervirens* L.) with allozyme markers. Individuals were selected for resistance against fungus *Seiridium cardinale* Wag. The comparison yielded information on changes in genetic variation due to artificial selection. The genetic structure of the breeding populations was similar to their base populations.

For *Fagus sylvatica* L. a study was conducted from Papageorgiou et al. (2008) for four beech populations growing on the Greek part of the Rodopi mountains were studied using morphological traits as well as DNA molecular markers (AFLPs and chloroplast DNA SSR). The aim of the study was to describe the variation patterns of beech in the Rodopi Mountains and to test the hypothesis of possible introgression between the beech subspecies' *sylvatica* and *orientalis* in this area. Results showed possible influence of *F. orientalis* on the east side of Rodopi and at the low elevations, while characters resembling *F. sylvatica* were observed mainly on the western part of the mountains and in higher altitudes.

Part 3: State of forest genetic resources conservation

6.1. *In situ* conservation of forest genetic resources

Greece joined EUFGIS network which was established as an information system in order to establish Gene Conservations Units across Europe (April 2007-March 2011) in close collaboration with the European Forest Genetic Resources Programme (EUFORGEN) and its member countries. The EUFGIS project was co-funded by the European Commission through the Council Regulation (EC No 870/2004) on genetic resources in agriculture. In addition to the national focal points, a large group of experts and scientists contributed to the development of the information system (http://www.eufgis.org/). In Greece on 2018, 15 Gene Conservation Units (GCUs) for *Pinus halepensis*, *Pinus brutia, Pinus nigra*, *Abies cephalonica* and *Abies borisii regis* were established (Table 4). Seed stands that were chosen proved to harbor high levels of genetic variation for the five conifer species (Alizoti and Aravanopoulos 2019).

Table 4. Gene Conservations Units established by EUFGIS. Species, region of establishment, geographic coordinates and area covered by each unit, (http://portal.eufgis.org/search/simple/list/?tx_wfqbe_pi1 [country_name] =Greece&tx_wfqbe_pi1 [target_species] =&tx_wfqbe_pi1 [unit_type] =).

Species	Region	Latitude/longitude	Area (ha)
Pinus halepensis	Euboia	38°43'15"N/ 23°29'20"E	96.77
	Kassandra	40°04'03"N/ 23°20'05"E	140
	Sithonia	40°10'26.0013"N/23°43'51.3869"E	90
Pinus brutia	Thassos	40°45'20.3208"N/24°44'19.8621"E	86
	Agios Nikolaos	35°11'10.1591"N/ 5°34'24.3311"E	100
	Chania	35°16'31.2047"N/23°57'24.1864"E	300
Abies cephalonica	Tripoli	37°36'35.5678"N/22°7'40.2173"E	210
	Kalamata	36°54'53.6455"N/ 22°24'58.2708"E	500
	Cephallonia	38°12'50.0637"N/20°35'57.7148"E	500
Pinus nigra	Metsovo	39°52'56.4333"N/21°13'14.8059"E	70
	Kastoria	40°21'00"N/ 20°55'00"E	98
	Drama	41°25'24.0855"N/24°30'32.8491"E	60
Abies borissi-regis	Evritania	39°7'41.9849"N/ 21°51'25.6613"E	56
	Katerini	40°4'42.9486"N/ 22°24'28.7622"E	200
	Trikala	39°32'35.6459"N/21°28'44.2493"E	200

Whereas Natura 2000 in Greece established 443 areas in the European network Natura 2000 (https://www.geogreece.gr/natura-list_en.php), which are divided to 202 Special Areas of Conservation (SACs) and 241 areas as Habitats Directive requires Sites of Community Importance (SCIs). The total area protected from Natura 2000 is about 4,300,000 ha. Although this area is considered as *in situ* conservation areas there are no collected data that also genetic resources of those areas were assessed.

Apart from those two European initiatives for establishment of GCUs and Natura sites, few more *in situ* conservations effort exist primary from national or international founded programs that were implemented from Universities, research Institutes and international collaborations.

In Crete, a conservation *in situ* program is implemented from 2010 for the relict tree genus *Zelkova* (http://www.abelitsia.gr/en/program/project). *Zelkova abelicea* (Lam.) Boiss. (Ulmaceae) is of outmost scientific and conservation interest as it is a Tertiary relict species and an endemic tree of the Mediterranean island of Crete, Greece. It is found in open, mountain forest communities between ~800 and ~1,800 m above sea level in all mountain massifs of Crete in the Lefka Ori, Psiloritis, Kedros, Dikti and Thripti. All these populations are significantly threatened by overgrazing and browsing by goats and sheep, soil erosion, drought, fire and the cutting of young branches for making "Katsounes", the traditional Cretan walking sticks. Given the level of threat to various populations, *Z. abelicea* has been included as Endangered (EN) on the IUCN Red List of Threatened Species and is protected by the Greek legislation (Presidential Decree 67/1981), the Bern Convention (Appendix I) and is also included in Appendices II and IV of the European Habitats Directive (92/43).In 2014, the Mediterranean Agronomic Institute of Chania in partnership with the University of Fribourg and in collaboration with the four Forest Directorates of Crete (Chania, Rethymno, Heraklio and Lasithi) implemented the first phase (2014-2016) of a project entitled: "Conservation of *Zelkova abelicea* in Crete" and are currently implementing its second phase (2017-2020). This partnership is funded by the Fondation Franklinia (www.fondationfranklinia.org).

A LIFE program was implemented also in Crete entitled: "Actions for the conservation of coastal dunes with *Juniperus* spp. in Crete and the South Aegean (Greece)", JUNICOAST from 01/01/2009

– 31/08/2013 in order to protect and conserve Coastal dunes with *Juniperus* spp. Which are classified as priority habitat (code 2250*) by the "Habitats Directive". The same program also implemented *ex situ* conservation actions and Seeds from *Juniperus macrocarpa* and all keystone species have been collected, cleaned and stored at the seed bank of Mediterranean Agronomic Institute of Chania (MAICh). More information can been found at http://www.junicoast.gr/.

Forest Research Institute of Thessaloniki has established pilot areas (Table 5) in many geographic regions for *in situ* conservation and for seed collection for various forest tree species (personal communication with Dr. Konstantinos Spanos).

Table 5. Taxon name geographic region, geographic coordinates and altitude.

Taxon name	Activities (Seed collection)	Geographic region	Latitude/Longitude/ Altitude
Acer platanoides	v	Volakas	41.22.34/23.59.41/750m
Acer pseudoplatanus	v	Lailia	41.15.02/23.34.57/1200m
Carpinus betulus	v	Nevrokopi	41.16.00/23.44.00/800m
Prunus avium	v	Kilkis (Pontokerasia)	41.05.00/23.08.26/650m
Prunus avium	v	Voras Mt.	40.54.56/21.57.11/570m
Quercus ilex	v	Olymbiada	40.35.10/23.47.46/5m
Sorbus torminalis	v	Kerdilia Mt.	40.47.09/23.38.11/850m
Fagus sylvatica	v	Chortiatis	40.35.30/23.07.09/800m

Fraxinus angustifolia	v	Melia	40.58.30/26.07.40/150-170m
Fraxinus angustifolia	v	Komotini	40.59.50/25.23.30/10-15m
Fraxinus angustifolia	v	Doirani	41.14.00/22.46.35/50m
Fraxinus angustifolia	v	Ierissos	40.27.50/23.49.00/15m
Fraxinus angustifolia	v	Omolio	39.53.00/22.37.00/20m
Fraxinus angustifolia	v	Evia	38.49.00/23.25.25/120m
Fraxinus angustifolia	v	Louros	39.09.00/20.45.00/50m
Fraxinus angustifolia	v	Kalavryta	37.56.00/22.04.00/870m
Fraxinus ornus	v	Stavroupoli	41.14.00/24.39.00/300m
Fraxinus ornus	v	Nevrokopi	41.16.00/23.44.00/800m
Fraxinus ornus	v	Nigrita	40.51.00/23.24.00/540m
Fraxinus ornus	v	Poligiros	40.26.50/22.24.41/570m
Fraxinus ornus	v	Kastania	40.26.37/22.24.41/300m
Fraxinus ornus	v	Stomio	39.52.00/22.39.00/380m
Fraxinus ornus	v	Melia	41.00.50/26.04.45/340m
Fraxinus ornus	v	Lidoriki	38.39.47/22.13.00/920m
Fraxinus ornus	v	Kalavrita	37.56.29/22.04.00/870m
Cornus mass	v	Vrodou	41.14.58/23.40.30/700m

Prunus spinosa	v	Nevrokopi	41.16.00/23.44.00/800m

Furthermore, the Mediterranean Agronomic Institute of Chania in 2000 founded a Seed Bank which holds collections of endemic, rare and threatened wild plants as well as other wild plants of Crete (medicinal, aromatic, etc.) and landraces of cultivated plants. The infrastructure of the seed bank provides for all the essential steps for the preservation of the seed germplasm, such as collection (well experienced personnel on collection of Cretan flora and on plant identification), seed drying (Drying Room with relative humidity 15-20% and temperature 15 °C) and storage (https://www.iamc.ciheam.org/en/research/plant_conservation_unit). In addition, there is a fully equipped laboratory for germination experiments (germination chambers with controlled temperature and light conditions, dark room with safety light for studies on seed dormancy, etc.). The same Institute has a botanical Garden, founded in 2001, which holds a collection of endemic and threatened plants for demonstration and education purposes. It is closely linked with the Seed Bank and covers an area of approximately 0.5 ha (https://www.iamc.ciheam.org/en/research/plant_conservation_unit).

6.2 Needs, challenges and opportunities for improving in situ conservation of forest genetic resources in your country

In situ conservation strategy have to further be improved in Greece, and a national program should be established in order to prioritize the species which need to conserved *in situ*. A lot of species that are endangered and belong to IUCN Red list of threatened species are present in Greece. According to the fact sheet prepared from Document prepared by Silvia Sánchez, Andrea Pino Del Carpio, Ana Nieto and Melanie Bilz from the European Union Representative Office for IUCN 12% of the 667 vascular plant species assessed in Greece are considered threatened at the European level. For example, *Juniperus drupacea* which is only present in the Oros Parnonas (Kai Periochi Malevis) Natura 2000 site (a Special Area of Conservation and a Site of Community Importance; EUNIS 2014) is considered endangered. Moreover, Greece has also a big list of monumental trees such as the plane Tree of Hippocrates in Kos Island, the plane tree of Pausanias in Aigion (https://www.geogreece.gr/fysis_en.php) etc. whereas they conserved *in situ* but further investigation for their unique genetic diversity and ex situ efforts must be incorporated in order to secure their future survival.

6.3 Priorities for capacity building and research in this area

The *in situ* national program must include cooperation from all stakeholders, Universities, Research Institutes, Non-governmental organizations (NGOs), Forest Services, Ministry of Environment and Climatic Change etc. in order to establish a master plan which will prioritize species that need further in situ protection.

Chapter 7. Ex situ conservation of forest genetic resources

7.1 Introduction

The first time that Greece implemented an *ex situ* program was due to a project that was funded by United Nations Development Program (UNDP) entitled UNSF/FAO/GRE: 20/230. The project aimed at enhancement of forest resources in Greece. It started at 1967 and finished at 1972, and covered a lot of functions of forest ecosystems such as: forest ecology, afforestation, soil research, forest fires, forest management, forest wood science, forest politics etc. In the project foresters from all over the world with collaboration of local foresters were employed in order to promote forest ecosystems in Greece. Under this project an afforestation program also began with N. E. Cooling as a coordinator, who established pilot provenances trial areas in 11 areas across country. The main species that were planted in those areas were *Pinus radiata*, *Pinus pinaster* and *Pinus brutia*. The final report was deposited from N. E. Cooling on 1971 and a copy of it is deposited in the Library of Mediterranean Forest Ecosystems -which was founded at 1944- and contains 7.700 volumes of books and 349 titles of scientific journals for forest section.

The second project that was funded from UNDP entitled: Forest Development – Afforestation (FO: DP/GRE/78/003) initiated at 1981 and lasted until 1986 under the coordination of N. E. Cooling and many other foresters. Under this project three pilot areas for afforestation were established; two on premenstrual *Quercus ecosystems* (NIgrita &Grevana regions) and one on evergreen broadleaves (Naupaktos region). The main species that were used in the Nigrita region for the establishment of those pilot areas were *Pinus pinaster*, *Pinus nigra* and *Pinus brutia.* Different provenances were tested for *P. nigra*, *P. pinaster*, *P. radiata* and *P. muricata*. The final technical report was produced at 1986 from E. N. G. Cooling and C. Varelides and contains all the results from the program. It is deposited also in the Library of Mediterranean Forest Ecosystems.

FAO established from 1977 to 1982, in Greece, a network of provenance trials has been established for both *P. halepensis* and *P. brutia*, to explore the levels of the existing variation for adaptive traits. This network consisted of five trial sites for *Pinus halepensis* and seven trial sites for *Pinus brutia* including both Greek and foreign materials. These were, for *P. halepensis*: three Italian, one from Spain, three Moroccan, five Tunisian and six other provenances form North African countries and, for *Pinus brutia*: two Turkish provenances and one from Cyprus.

An initial breeding effort that was launched in Greece, which mainly involved hybridization efforts between *Pinus brutia* and *Pinus halepensis*. Later in 1970, organized breeding programmes were initiated, with selection and collection of material on a provenance and mother-tree basis. Both *P. halepensis* and *P. brutia* provenances exhibited high genetic variation for all the adaptive traits studied, while their performances across sites indicated the high potential for effective across-site selection (Matziris 1997; Alizoti et al. 2000). *P. brutia* provenances of Greek origin outgrew the provenances originating from Turkey and Cyprus when tested in two different sites (Alizoti and Aravanopoulos, 2001). The outstanding performance of *P. brutia* × P. *halepensis* hybrids was remarkable, due to the fact that when they compared with their parental species in harsh environmental conditions they significantly outperformed in relation to the only parent that was able to survive (*P. brutia*). The results indicate the existence of high genetic germplasm among and within the natural populations of both species for adaptive traits (Matziris 2000), the potential for selection and breeding and the need for conservation of their unique genetic resources in the face of global change. A first-generation seed orchard exists for *Pinus halepens*is covering 20 ha and including 76 genotypes (2,630 grafted individuals in total). There are two progeny trials associated with this seed orchard, established in 1987, with 70 open-pollinated families that correspond to 70 out of the 76 clones from the seed orchard.

7.2 Seed Orchards

7.2.1 Establishment from the Institute of Mediterranean Forest Ecosystems (Laboratory of Forest Genetics, Biotechnology and Silviculture)

Four first generation clonal seed orchards have been established in the decade 1978–1987 for *Pinus nigra* (Arn.), *Pinus halepensis* (Mill.), due to their economic and ecological importance for the country (Matziris, 1993, Matziris, 1997) from. The species are extensively distributed in the country and produce mainly wood and non-wood products supporting partially the rural economies.

The main timber productive species in Greece is *Pinus nigra*, along with *Abie*s sp., resulting in the first breeding efforts in the country, by the establishment of three clonal seed orchards located in different geographic zones. Moreover, the needs for improved forest reproductive material for reforestation purposes were covered by the establishment of clonal seed orchards that could be used even for commercial plantations. In Central Greece two clonal seed orchards, in the Fthiotida and Trikala regions, have been established in 1981. The first seed orchard includes 91 *P. nigra* clones, derived from selected intensively plus trees growing in the natural populations of Pindos mountain range. The second seed orchard comprises of 49 phenotypically selected clones of the introduced black pine variety *P. nigra* var. *austriaca*. In Southern Greece a clonal seed orchard was established in 1978 in Northwest Peloponnese (Elea region) (Matziris, 1993). The seed orchard consists of 52 clones, selected as plus trees from four natural black pine populations of the Peloponnese; namely Mt. Parnon, Mt. Taigetos, Feneos and Zarouchla areas. A *Pinus halepensis* (Mill.) clonal seed orchard has also been established in 1987 (Matziris, 1997). The seed orchard comprises 76 clones, derived from selected plus trees growing in Euboea region and is located in the Central-Western part of the country (Aitoloakarnania region).

Pinus spp.'s clonal seed orchards are forming ex situ conservation, preserving plus phenotypes originating from different natural, potentially marginal/peripheral, populations. Two of the above mentioned seed orchards, one *Pinus halepensis'* and one *Pinus nigra's*, have been progeny tested (Matziris, 2000, Matziris, 2005).

7.2.2 Establishment from the Department of Forestry and Natural Environment, Aristotle University of Greece (Laboratory of Forest Genetics and Tree Breeding)

According to Alizoti et al. (2019) a clonal seed orchard located in Northern Greece (Chalkidiki region) for *Pinus nigra* was established in 1980. The clonal seed orchard comprised of 60 clones, derived from intensively selected plus trees in five natural populations of the species growing in the Central Macedonia region; namely Mt. Olympus, Mt. Pieria, Mt. Vermion, Chalkidiki peninsula and Thassos island (Alizoti et al. 2010). Furthermore, a clonal seed orchard was established the same year for *Abies borisii regis* in the same region with clones selected from the central Pindos mountain region. Those two seed orchards have been progeny tested according to Alizoti et al (2019) and if thinned following the termination of selection for breeding, could develop onto *ex situ* stand containing large part of the original genetic diversity.

7.3 Provenance, Provenance-Progeny Tests, Clonal Archives

7.3.1 Establishment from the Institute of Mediterranean Forest Ecosystems (Laboratory of Forest Genetics, Biotechnology and Silviculture*)*

Several provenance and provenance-progeny trials are established during the 1970s and 1980s the species under investigation were: *Pinus nigra* (Arn.), *Pinus brutia* (Ten.) and *Pinus halepensis* (Mill.).

During the 1970s and 1980s, seven provenance trials were established for *Pinus nigra*, four of which located in Northern Greece, two in Thrace and one in Central West Greece (Varelides, 1997, Varelides et al., 2001). Ten Hellenic black pine populations are tested in those trials, while three of them include also genetic material from France (3 populations), Turkey (5 populations), Italy (1 population) and Spain (4 populations) (Varelides 1997, Varelides et al. 2001).

For *Pinus brutia* a multi-environmental trial, including five provenance tests and one provenance-progeny test, was established in the 1970s and 1980s (Panetsos, 1981). Seven populations were tested that represented almost all the natural range of the species in the country. The trials were almost all around the country and were all located out of the natural distribution of the species, expect for the one located in the North part and specifically in the Evros region. An additional trial was established in the Central West part of the country and included the two northernmost and marginal Hellenic populations of the species; namely the Alexandroupolis and Thassos ones, together with four populations of Turkish origin (Panetsos 1981; Matziris 1979).

A multi-environmental trial was established for *Pinus halepensis* in the early 1970s that included two provenance-progeny trials, located in Central Greece (Fthiotida and Viotia regions), and a provenance trial located in Northwest Peloponnese (Panetsos 1981). In some trials, additionally to the Hellenic provenances, eighteen exotic ones originating from Italy (3 populations), Spain (1 provenance), Morocco (3 populations) and Tunisia (11 provenances) were also tested (Panetsos 1981).

In addition to the above trials, provenance tests were established in the country in the framework of FAO network of trials for several exotic species, as for example *Pinus pinaster*, *Pinus radiata*, *Pinus muricata* (Matziris, 1979, Matziris, 1981, Matziris, 1995, Matziris, 1996)(Matziris 1979, Matziris 1981, Matziris 1982, Matziris 1995, Matziris 1996), but also *Pinus controrta*, *Pinus maritima*, *Pinus strobus* and *Pseudotsuga menziesii. Pinus pinaster* was the species tested more intensively in nine provenance trials, established at seven sites across the country; two trials in North West Greece, two trials in Central Macedonia, one trial in Thrace, one trial in Euboea, two trials in Central West Greece and one trial in South Greece (Peloponnese) (Matziris 1981). In those trials, provenances of French and Portuguese origin were tested for their growth and adaptive potential. All the above mentioned experimental trials, established in the framework of breeding activities, may serve as static ex situ conservation plantations, harboring an ample part of the existing within population variation at the places of origin during the time of sampling.

7.3.2 Establishment from the Department of Forestry and Natural Environment, Aristotle University of Greece (Laboratory of Forest Genetics and Tree Breeding)

According to the Alizoti et al (2019) other species that have been studied in provenance and provenance- progeny trials are *Pinus sylvestris*, *Abies sp*. and *Castanea sativa* with years of establishment 1970s, 1980s and 2002. For *Pinus sylvestris,* three provenance trials, two of them in Northern Greece and the third one in Central Greece existing. According to Moulalis (1984), 14 Hellenic populations, covering the southernmost populations of the species in the Europe and the country, are planted together with two populations from the Northern Macedonia and two from Bulgaria.

Furthermore, in 1974 an *Abies* species- provenance trial has been established in Central Greece in order to test four species and a hybrid (*A. alba, A. cephalonica, A. equi- trojani, A. bornmuelleriana, A. concolor* and the hybrid *A. x borisii regis)* and 21 Greek provenances of Abies borisii regis. (Panetsos, 1990; Donta et al., 2010).

Under CASCADE EU Project in Central Greece (Chalkidiki region) a *Castanea sativa* provenance-progeny trial was established in 2002. In total 6 provenances from contrasting environments of Spain, Greece and Italy were tested (each population was represented by 26 open pollinated families) and a number of publications were produced (Fernandez et al., 2005; Tchatchoua and Aravanopoulos 2010a, b; Nikolaou et al., 2011).

Lastly clonal archives of *Populus sp., Platanus orientalis, Platanus occidentalis, Platanus acerifolia and Prunus avium* were established. For the *Platanus* and *Populus* species the clonal archive exists in Central Macedonia and molecular fingerprinting was also implemented indicating the high genetic diversity (Malliarou et al., 2014; Mitsiou et al., 2013; Vaxevanidou and Aravanopoulos 2002). In Eastern Macedonia, a gene bank for elite *Prunus avium* genotypes – a high economic value wood- exist with availabele information for DNA fingerprint (Avramidou et al., 2010). Lastly, according to Alizoti et al (2019) a series of *Populus* and *Platanus* clonal trials have been established for the evaluation of clonal biomass production.

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

The forest reproductive material which is widely used in every country is essential for maintaining biodiversity, ensuring adaptation and resilience capacity of the populations, and for conservation purposes. An initial effort for seed storage has been made in 1989, when a Central Forest Seed

Warehouse (CFSW) was established from the Ministry of Environment and Climatic Change under the supervision of Dr. Despoina Paitaridou. In 2004 the CFSW is modernized and contains all the appropriate equipment control and certification of forest propagation material and cold rooms for the maintenance of seed stocks in appropriate conditions and temperatures. Today the CFSW stills operated with limited employed staff and limited financial resources. Furthermore, in Greece under the supervision of Forest Services numerous forest nurseries existed with the obligation to collect and reproduce from natural seed stands various species (*Pinus halepensis*, *Pinus nigra*, *Cupressus sempervirens* etc). This forest plant material was freely available for reforestation purposes, for citizens and for internal needs of each municipality. Due to the economic crisis in Greece, those forest nurseries did not get any additional funding from the Ministry and this resulted to their closure. Recently with a Law published from the Official Government Gazette (FEK: 2564/27 November 2015) the requirement for "Establishment of Forest nursery" was published.

Chapter 9. The state of genetic improvement and breeding programs

Tree breeding programs was initiated in 1970's in Greece, selection of forest trees was performed according to phenotypic characteristics or according to resistance to pathogens; plus trees was selected and by assisted crossing, seeds were planted in different areas of Greece.

The Mediterranean cypress (*Cupressus sempervirens* L.) is an essential part of the landscape, economy, history, tradition and culture of most Mediterranean countries. In Greece, it forms natural stands on the islands of Crete, Rodos, Kos, Samos and Symi. A breeding programme for Greek cypress populations started in autumn 1981. Ten years later, the evaluation of all experiments revealed that only 5% of the initial seedlings examined were characterized as resistant; these were grafted in clonal archives (Xenopoulos 1990).

Following experiments from Xenopoulos 1990, according to Avramidou et al. (2017) in year 2010 a full sib family of *Cupressus sempervirens* L. was established in Crete region. The full sib family consisted of 382 individuals derived from a controlled cross between elite plus trees, namely the female horizontalis parent R93130 and the male pyramidalis parent S82122. Parental trees originated from unrelated natural populations from the Rhodes and Samos islands in the Aegean Sea, respectively. R93130 and S82122 were also selected based on their differential resistance to the fungus *Seiridium cardinale*, according to an artificial inoculation test (Xenopoulos 1990 and personal communication). The mapping population was screened using Amplified Fragment Length Polymorphism (AFLP) and simple sequence repeats (SSR) markers for constructing genetic maps of the horizontalis and pyramidalis varieties used as parents, as well as a consensus map covering all chromosomes of the cypress genome. The consensus *C. sempervirens* map (LOD = 6, θ = 0.30) consisted of 11 linkage groups and covered 2.105.65 cM. The consensus map was used for QTL detection regarding crown form, resistance to the fungus *Seiridium cardinale*, height, and diameter. A QTL for crown form architecture was found in linkage group 11 with a LOD score 3.30 (Avramidou et al. 2017).

Chapter 10. Management of forest genetic resources

In Greece according to Forest 2015 the percentage of public forest was 74.5% while for private forest 21.6%. According to the First National Inventory of Forest (1992) the distribution of forest and other wooded land by ownership structure are shown in Table 6. As it is already mentioned management of natural public forests is under the supervision of Forest Services. As a consequence, public forest management is being implemented by local authorities of public forest services in Greece. Currently there are 7 General Directorates of Forests and Agricultural Affairs, 31 Forest Directorates and 80 Forest Services covering the total area of Greece. Sustainable forest management is being implemented in Greece in all public forest areas. The Forest services have the obligation to create and perform a 10-year management plan for each forest unit according to its peculiarities. The forest management plan is mainly a technical report focusing on sustainable timber yield without taking into account consideration the non-timber products and services of the forest resource.

Table 6. Percentage of forest and other wood land according to the First National Inventory of Forest (1992).

Status	Forest (1000ha)	%	Other wood land (1000 ha)	%	Total forest land	%
State	2200	65.5	2626	83.3	4826	74.1
Community	403	12.0	183	5.8	587	9.0
Private	269	8.0	154	4.9	423	6.5
Other	487	14.5	190	6.0	677	10.4
Total	3359	100	3154	100	6513	100

Part 5: State of capacities and policies

In Greece, a national coordination mechanism on forest genetic resources does not exist.

The main stakeholders that take part on the conservation, assessment and management of FGR are:

1. The Institute of Mediterranean Forest Ecosystems, Athens ELGO-DIMITRA
2. The Forest Research Institute, Thessaloniki, ELGO-DIMITRA
3. The University of Forestry and Natural Environment, Aristotle University of Thessaloniki
4. The University of Forestry and Management of the Environment and Natural Resources, Democritus University of Thrace
5. Forest Services in a general aspect which have the obligation to protect and manage forest ecosystems.
6. Department of Forestry and Natural Environment Administration, Karditsa
7. Department of Forestry and Management of Natural Environment, Karpenisi
8. Department of Forest and Natural Environment Sciences, Drama

Legislation associated with FGR in Greece

Greek forest ecosystems began to be protected nationally in 1937. They are largely preserved due to national and local legislation focusing on the natural conservation and genetic conservation of forest genetic resources (Alizoti and Aravanopoulos, 2019).

Law 856/1937, published in the Government Gazette, was the first law to protect natural ecosystems and their biodiversity. The first national forest parks established in 1938 were those of Mount Olympus and Mount Parnassos (Alizoti and Aravanopoulos, 2019).

Today there are ten national forest parks: Parnitha, Sounio, Pindos, Oiti, Prespes, Vikos, Samaria, Parnassos, Ainos and Olympus. The National Forest Parks of Prespa, Vikos, Pindos, Oiti and Sounio include both the cores and the peripheral zones, while the rest include only the forest cores (Hellenic Ministry of Environment). These cores are strictly protected and no human intervention is allowed, while in the peripheral zones limited human intervention may be allowed.

In addition to the national forest parks, 17 National Parks were identified in 2011 which are: the National Park Schinias - Marathon, the National Park of Koronia-Volvi, the National Park of North Pindos, the National Park of the Mesolonghi Lagoon, Ygikos National the National Forest Park of Dadia - Lefkimmi - Soufli, the National Park Delta of Evros, the National Park of Amvrakikos Wetland, the National Park of Eastern Macedonia and Thrace, the National Park of the Rhodope

Mountains, the National Park of Delos - Arios Park Delos , the National Park of Wetlands Kotychi - Strofilia, the National Park of Tzoumerka, Peristeri and Arachthos Gorge, the National Park of Helmos - Vouraikos, the National Marine Park of Alonissos, the National Park of Psalidia and the wetland of Kos, the Nature Protection Areas of the rivers Acheron - Kalama and the Nature Protection Area of Lake Kastoria.

In addition, 19 Aesthetic Forests were defined based on law 996/71, which include forest landscapes of a special aesthetic and ecological interest and aim at nature protection and recreational activities.

The Preserved Monuments of Nature in Greece are 51 and include individual trees or clusters of trees of special botanical, ecological, aesthetic, historical or cultural value. Areas of significant ecological, paleontological, geomorphological or other interest fall into the same category. In addition, 610 areas have been designated in natural ecosystems that serve as wildlife refuges (Ministry of Environment).

A milestone for the protection of the natural environment was the Constitution of 1975 with articles 24 and 117 which provided for the first time the constitutional protection of the environment. According to Article 24 (1), subparagraph (a), "the protection of the natural and cultural environment is an obligation of the State". This obligation is further clarified in the same article, paragraph 1, subparagraph b 'and states that the state is obliged to take special preventive and repressive measures to preserve the natural and cultural environment.

With the revision of the Constitution in 2001, the environment was recognized as a right of all and the principle of its sustainability and protection for the benefit of future generations was established (Koutoupa - Regkakou 2005). Article 117 of the Constitution, paragraph 3, stipulates that public or private forests or forest areas that have been destroyed burned or have been deforested in the present or in the past in any way, do not lose their status before they were destroyed. That is, they are declared as areas for compulsory reforestation and cannot be used for any other purpose. Paragraph 4 of the same article provides that the compulsory expropriation of forests or forest areas, belonging to natural or legal persons of private or public law, is allowed only by the State, for reasons of public benefit while their status as forests or forest areas remains unchanged.

According to the law 1650/1986 "For the protection of the environment", articles 18 and 19 define the environmental zones of different level of protection, i.e. the areas of absolute nature protection, the national parks, the protected natural formations, the landscapes and their characteristics, as well as ecological development areas. Article 19 defines:

1. The areas of absolute nature protection that are: the sensitive ecosystems, the habitats of rare or endangered species of flora and fauna and the areas that play a decisive role in the life cycle of rare or endangered wildlife species. Any human activity is prohibited in these areas. In special cases, scientific research or work aimed at preserving the characteristics of these areas is permitted.

2. The nature protection areas that are: the extensive areas of high ecological and biological value and in which the natural environment is protected from any activity or intervention that could potentially change its condition, composition or evolution. Scientific research, projects and especially traditional activities are allowed only if they do not contradict the objectives of protection.

3. National parks that are: extensive terrestrial, aquatic or mixed areas, which are not affected by human activities and host a large number of important biological, ecological, geomorphological and aesthetic elements. When all or part of the park is a forest or marine area, then it can be designated as a National Forest Park or a National Marine Park. For the protection of the Parks, special measures are taken, in order to be protected from natural causes, human actions, interventions and activities that lead to their degradation. According to the current operating and management regulations, scientific research and traditional activities are allowed.

4. The protected natural formations that are: the functional parts of nature or the isolated natural formations of special scientific, ecological or aesthetic value. They can also be areas that are important for the conservation of natural processes or natural resources. All activities that may cause their destruction, deterioration and deterioration are prohibited.

5. The ecological development areas that are: areas of special interest and value, due to their natural and cultural characteristics and their possibilities for the development of activities that are harmonized with the protection of nature and the landscape.

According to Law 3044/2002, twenty-five Management Bodies have been established, while two more were created after the Presidential Decrees Government Gazette 395/2000 for the National Park Marathon - Schinias and Government Gazette 906A / 1999 for the National Marine Park of Zakynthos (Ministry of Environment and Energy).

The Natura 2000 network is a pan-European nature conservation program for species and their habitats and the cornerstone of European conservation policy. Its goal is the long-term conservation of the most valuable and most endangered species and habitats. It started in 1992 and consists of two categories of areas: special bird protection zones as defined in Directive 79/409/EEC "on the conservation of wild birds" and sites of Community importance as defined in Directive 92/43/EEC. Greece has designated 202 special protection zones and 241 sites of Community importance, covering a total area of approximately 5.5 million hectares (Ministry of Environment). The two types of Natura 2000 sites may overlap in terms of the land they cover. The Natura 2000 network also includes the majority of protected areas under national law, as well as internationally classified sites.

The Ramsar Convention was ratified in Greece by Law 191/1974 and eleven of the most important wetlands in the country were designated as protected under it. Its first goal is the protection of high priority wetlands and the second is the protection of wetlands as ecosystems in combination with waterfowl, but also other species of fauna and flora. On the occasion of the Ramsar Convention, a global wildlife protection campaign was launched, resulting in:

1. The UNESCO Convention for the Protection of the World Cultural and Natural Heritage was ratified by Greece by Law 1126/1981. Two areas in Greece were recognized as sites of the World of Cultural and Natural Heritage, the area of Meteora and Mount Athos.

2. The Convention on International Trade in Endangered Species of Wild Fauna and Flora - CITES was ratified by Greece by Law 2055/1992. The CITES Convention regulates international trade in wildlife, which applies to all countries when importing or exporting wildlife.

3. The Bonn Convention concerning the conservation of migratory species of wild animals as well as the main provisions for habitats in Greece were ratified by Law 2719/1999.

In 1979, the European Ministerial Conference on the Environment signed the Convention on the Conservation of European Wildlife and Natural Habitats in Bern. The Berne Convention is quite similar to the provisions of Directive 79/409/EEC on the conservation of wild birds, but is much broader in terms of the protection of species and habitats. The purpose of the contract is to protect the species of wild flora and fauna and their habitats. In Greece it was ratified by Law 1335/1983.

The Convention on Biological Diversity, which was based on raising global awareness for the need for sustainable development, entered into force on 29 December 1993, after being signed by 196 nations. This Convention is the main tool for addressing the issues of biodiversity conservation and sustainable use of its constituents, as well as the equal and equitable distribution of the benefits arising from the use of genetic resources. In Greece it was ratified by Law 2204/1994.

The Cartagena Protocol on Biosafety was approved and signed in 2000 as a supplement to the Convention on Biological Diversity. It entered into force on 11 September 2003 and is an international treaty controlling the movement of genetically modified organisms between countries. Its importance lies in the recognition of the right of the signatory countries not to accept genetically modified organisms, based on the "precautionary principle". The Cartagena Protocol was ratified in Greece by Law 3233/2004.

The Barcelona Convention defines nine protected areas, six of which are forest ecosystems. The Biogenetic Reserves of international or regional interest that have been defined are: the Virgin forest of Central Rodopi, the main areas of Olympus, Ainos, Samaria, Oiti, the Pindos National Park, the Cedar Forest in Prespes, the Aesthetic Forest Kouri-Almyrou, the natural monuments of the forest Haidou-Koula, the forest of Lessini, the evergreen forest of Platanos, the mixed forest of Almopia-Aridea, the forest of cypresses in Ebona Rhodes, the mixed forest of Agios Grammos, the Forest of Paran and the Lagana-Zakynthos Forest. Also, two Biosphere Reserves have been designated: the Olympus National Park and the Samaria Gorge, while Mount Athos has been designated as a monument of international heritage.

Under current law, protected areas are managed by management bodies, public services, special services and legal entities or bodies designated for this purpose via management contracts. The management of protected areas is based on the 5-year Management Plans that identify the priorities for the implementation of projects, actions and measures aimed at the effective protection and management of protected areas.

The Hellenic Nature Committee 2000 is the central scientific advisory body of the State for the coordination, monitoring and evaluation of policies and measures for the protection of Greek biodiversity. The Ministry of Environment and Energy is responsible for its operation. The Commission's main responsibility is to monitor and enforce the provisions of the Habitats Directive for all Natura 2000 sites in the country. The Commission also acts as a National Committee of Protected Areas, with the responsibility of coordinating, monitoring and evaluating the action plans, and the organizational and operational capacities of the National System of Administration and Management of Protected Areas. The Commission records, classifies, coordinates, controls and evaluates the work and activities of the management bodies. In addition, it proposes to the appropriate Ministries the general measures and actions to be taken for the protection of nature and the sustainable development of the protected areas and coordinates the distribution of resources to the Managing Bodies for the achievement of their objectives.

International efforts to improve the management of forest genetic diversity and resources began at least 40 years ago (FAO 1975, 1989). In 1975 the FAO characterized the lack of knowledge on the minimum size that a genetic conservation unit of forest trees should have problematic. Shaffer (1981) and Ryder (1986) introduced the concepts of "minimum viable population" and "evolutionary significant units", contributing to the integration of genetics into conservation which subsequently led to the dynamic conservation approach applied to forest trees (Namkoong et al., 1996).

At European level, biodiversity policy is mainly guided by ministerial conferences on forest protection and the "Environment for Europe" policy. The first Forest Europe Ministerial Conference adopted a resolution establishing EUFORGEN - the European Forest Genetics Program. EUFORGEN is an international cooperation program that promotes the conservation and sustainable use of forest genetic resources in Europe, as an integral part of sustainable forest management. Greece participated as a member of EUFORGEN, as well as in the EUFGIS expert group that developed the minimum pan-European requirements and data standards needed for dynamic Gene Conservation Units (Koskela et al., 2013, Lefèvre et al., 2013). This created a pan-European network of dynamic gene conservation units. Lefevre et al., (2013) assessed this network on the basis of information available on the EUFGIS portal, species distribution maps and environmental stratification in Europe. The analysis of eleven species revealed that for almost all species the peripheral areas of their distribution were not covered by the network. As a result, a combination of species and site-oriented strategies has been proposed to achieve effective conservation of genetic resources.

As previously mentioned in 2018, a National Strategic Plan for Forests was voted as a Law (FEK 5351/28/11/2018) and published in the Official Gazette of the Government with a horizon of 20 years (2018-2038). The main target that was adopted was "Preserve sustainability and increase the contribution of forest ecosystems in economy of the country through multifunctionality, adaptability and enhancement of socio-economic role, under the prism of climate change. In this NSPF one of the main targets is 2.2.5 which refers to: "Evaluation and utilization of forest genetic variation and selection of genetic material which presents adaptation to climatic changes. The selection and utilization of endemic genetic material resistant to stress is a direct action towards mitigation of climate change which also protects the distribution of marginal/peripeheral populations. Furthermore, cooperation between research institutes, universities, forest services and management bodies for protection is required." In the same NSPF, an indicator for assessing the *in situ* and *ex situ* collections of species by recording them in detail also exists.

What is the state of research and development on forest genetic resources in your country?

<u>What is the state of education and training on forest genetic resources in your country?</u>

Education for FGR management and conservation is mainly provided from the two Universities, University of Forestry and Natural Environment, Aristotle University of Thessaloniki and University of Forestry and Management of the Environment and Natural Resources, Democritus University of Thrace. Those two Universities teach Forest Genetics and Breeding as a mandatory lesson in order to acquire a bachelor degree, and also have Master's and Phd positions for students. The other three departments (Department of Forestry and Natural Environment in Drama, Department of Forestry and Natural Environment Administration in Karditsa and

Department of Forestry and Management of Natural Environment in Karpenisi) which were recently integrated with Universities did not teach forest genetics at their students for bachelor degree neither master or Phd thesis. The two Institutions that also serve forest sector in general and have departments for forest genetics (the Institute of Mediterranean Forest Ecosystems in Athens and the Forest Research Institute in Thessaloniki) primarily serve as research Institutes with no obligation and with limited possibility to teach for forest genetics, although some attempts were made on the platform of educating children through personal responsibility of researchers. Furthermore, an education material and seminars were recently produced from the Institute of Mediterranean Forest Ecosystems, under a National funded program entitled: Experiential actions with the educators in the forest (GREEN FUND funded) which aimed at educating teachers for forest genetics, management, insect invasions, biodiversity, ecophysiology of forest trees and ecology. Furthermore, through LIFE funded programs numerous attempts have been made, under dissemination obligations in order to educate young children for forest genetic resources, for example LIFEGENMON (LIFE13 ENV/SI/000148) produced and freely disseminate three books for children entitled: Journey to a Big Forest, Guardians of the Forest and Forest Diary in English, Slovenian, German and Greek language and teaching materials for school and kindergarten entitled: "Handbook for Learning and Play in the Forest" in English and Slovenian language (http://www.lifegenmon.si/project-publications/).
Establishment of a national core network of forest genetics researchers must be implemented in order to educate young children, citizens, teachers, foresters, owners of private forest about the significance of conservation and management of FGR. Education must be implemented from the basic level starting from the term of genetic variation and why protecting and manage genetic variation ensures adaptation and sustainability of species and forest ecosystems.

- *What are the needs, challenges and opportunities for strengthening the national (or sub-national) institutional framework on forest genetic resources?*

In Greece the urgent need to develop a national programme for managing and conserving

FGR with multistakeholder participation is the basic step to ensure sustainability of FGR. Establishment of nationals networks for FGR, networking among stakeholders should be also be promoted.

 What are the priorities for capacity-building in this area?

In Greece, research and education need to be strengthened in all areas of FGR management and at both technical and professional levels. Moreover, utilization of recent developments in forest inventory (remote sensing, GIS) and forest genetics (traditional and more recent molecular marker) should be implemented in the management of FGR. A series of actions that include: a) promotion of programmes related to FGR with collaboration among national institutions, b) strengthenings of educational and research capacity in order to incorporate recent technical advantages in the management and conservation of FGR, c) raising awareness and participation in FGR management of local communities in order to promote decentralization, d) promotion of regional mechanisms for forest reproductive material for research and development, e) promotion of regional and international cooperation in order to support education, knowledge dissemination, f) promotion of public and international awareness of the role and value of FGR

Part 6: Challenges and opportunities

Under the climate change effects, the recently pandemic expansion for COVID 19, the human intervention and the abiotic threats on forests the challenge of sustainable food security is the main perquisite for the survival of humans. FGR conservation and management should be incorporated into every day's life of humans through a national framework which will aim at better strategies and practices, better protocols and effective plans for the resilience of forests.

Genetic diversity is the fundamental principle, which ensure species survival and adaptation for forest ecosystems, while diversity among species promote the resilience and adaptation on species lever under climate changes.

Greece has an enormous biodiversity richness, and ranks fourth in the Mediterranean region according to Dernegi (2010), while marginal-peripheral populations which may contain specific "genetic variation" which will favor adaptation to the ongoing environmental extremes for several species are also present.

Availability of information on forest genetic resources

Several attempts for conservation of FGR were made the last years. As it was already mentioned ex situ conservation initiated at 1967 and from then several provenances trials seed orchards, were established. The establishment of a Central Forest Seed Warehouse (CFSW) in 1989, by the Ministry of Environment and Climatic Change under the supervision of Dr. Despoina Paitaridou was also a step forward conservation. Also establishment of 15 GCUs from EUFGIS network on 2018 further assisted these efforts of conservation. Furthermore, after the discovery of molecular markers several attempts of various Research Institutions, Universities through National, European programs or through own costs tried to halt genetic diversity and variation of various forest species. Whereas a lot of economic and human resources were spent through these years towards conservation of FGR, the information is rather limited or unavailable. The lack of existence of a National FGR system which could merge and obtain all this scientific information for future use is one of the bigger problems. The information for FGR conservation can only be assessed through publications, national conference proceedings, and sometime from personal communication with retired researchers who worked on the projects.

• Conservation of forest genetic resources

Although, "in situ" conservation units for forest species exist in Greece mostly further development and protection must be succeeded in order to protect and conserve the valuable genetic pool that exists in Greece. There is a lack of economic resources that can be used for conservation and protection of FGR in Greece. External funding from Europe through several calls (LIFE, H2020) are been deposited from the Universities and Research Institutes but there is not a National program for conservation and protection of FGR. Furthermore, although the establishment of a Central Forest Seed Warehouse, nowadays face difficulties of maintenance due to economic reasons. An important key stone step would be the establishment of a National forest genetic bank where seed from all important species would be properly stored and maintained for future usage.

• Use, development and management of forest genetic resources

Management of FGR plays an important role in conservation and protection, but in Greece which harbors so many endemic forest species no attention is given to FGR. While Greece ‘s forest land is mostly public managed in relation to sustainable forest management practices, due to anthropogenic and economic limitation

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