THE SECOND REPORT
ON THE STATE
OF THE WORLD'S

FOREST GENETIC RESOURCES

COUNTRY REPORT

LITHUANIA

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

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

THE SECOND REPORT ON

THE STATE OF THE WORLD'S FOREST GENETIC RESOURCES

REPUBLIC OF LITHUANIA

June 2020

Preface

Forest genetic resources are the national treasure that guarantees the sustainability, productivity and quality of forest ecosystems. Conservation of forest genetic resources ensures a success of biodiversity, which is assumed as a public good as well. Forest genetic resources constitute a base for forest tree breeding and seed farming, developed on eco-genetic approach by selecting valuable natural populations and genotypes and at the same time collecting and testing their progenies in progeny trials or running it in archives of clones, seed orchards etc. Forest tree breeding and genetic conservation system includes both *in situ* and *ex situ* measures: genetic reserves, seed stands, plus trees, clonal archives (collections), seed orchards and gene banks.

Given the long-term nature of tree selection and improvement and the need for continuity in conservation activities, an overall strategy is needed at the national level to guide activities over a period of decades. The main players in this field are experts from the Lithuanian Research Centre for Agriculture and Forestry (LRCAF), Institute of Forestry, who hand in hand with State Forest Service provide direction and coherent policy guidance for an area that encompasses regulations, measures and clear recommendations on developing a national strategy to underpin the conservation and development of forest genetic resources in Lithuania.

Acknowledgements

This report required the dedicated input of a team of the leading national experts from State Forest Service in the field of forestry statistics, especially Darius Vižlenskas. We are deeply grateful to the team for having the opportunity to contribute in writing this report, and also to the highly devoted colleagues from LRCAF acad., habil. PhD Alfas Pliūra, PhD Virgilijus Baliuckas for getting numerous hints and improvement of several topics. Furthermore, we are grateful to Vaiva Kazanavičiūtė for the input and efforts to improve the language quality of this report.

Abbreviations and Acronyms

FRM – Forest Reproductive Material,
FRG - Forest Genetic Resources
LRCAF - Lithuanian Research Centre for Agriculture and Forestry
SFS - State Forest Service
SSPA - State Service for Protected Areas

PGR - Plant Genetic Resources
AGE - Advisory Group of Experts for R&D of FGR
FGN - Forest Genetic Network

Executive summary

Conservation and increase of forest and forest genetic resources is one of key policy implementing directions in National Environmental Protection Strategy (p. 21, page 37).
According to this Strategy, increase in the forest coverage to 35 % of the total country territory by 2030 is anticipated. In order to increase forest resources is prerequisite of use of high quality FRM, valuable in terms of selection and derived from the only registered type of basic material. In general, this material is derived from the valuable forest conservation units. Therefore, establishment and sustainable development of FGR is crucial in the long term. There are many players dealing with this mater in Lithuania - starting from organization, implementing activities related to FGR establishment and development, and finishing by policy makers in the Ministry of Environment. The management of genetic resources and forest tree breeding have been assigned to the different institutions in Lithuania. For this reason, the multi-disciplinary researches and cooperation between organizations are required.

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

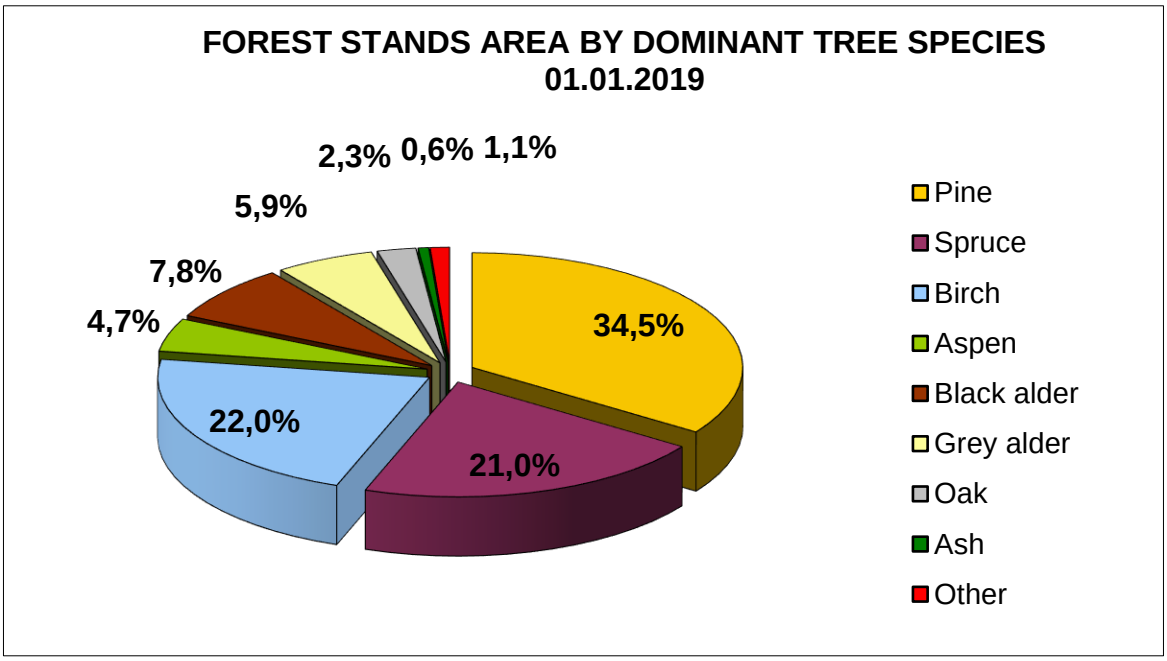
Chapter 1. Value and importance of forest genetic resources

Forest land area was 2,197,100 ha and covered 33.7% of the country's territory on the 1st of January 2019. Since the 1st January of 2003, forest land area has increased by 151,800 ha corresponding to 2.4% of the total forest land cover. During the same period, forest stands expanded by 107,600 ha to 2,058,600 ha.

Occupying 1,145,600 ha, coniferous stands prevail in Lithuania, covering 55.6% of the forest area. They are followed by softwood deciduous forests (844,800 ha, 41.0%). Hardwood deciduous forests occupy 68,200 ha (3.3%).

The total area of softwood deciduous forest increased by 146,400 ha over the last sixteen years. The area of hardwood deciduous forest has decreased by 24,400 ha (mainly due to dieback of ash stands) and coniferous forest - by 14,400 ha.

Scots pine occupies the biggest share in Lithuanian forests – 710,600 ha. Compared to 2003, the area of pine decreased by 900 ha. Norway spruce stands covers 432,600 ha, with a reduction of 12,700 ha since 2003.



Birch stands cover the largest area among deciduous trees. Since 2003, it increased by 60,300 ha and reached 452,400 ha by the 1st of January 2019. Area of black alder increased by 41,800 ha, to 161,300 ha. The area of grey alder decreased by 300 ha reaching 121,700 ha. The area of aspen stands expanded by 38,600 to 96,000 ha.

The area of oak stands increased from 35,700 ha to 47,300 ha. The area of ash stands decreased more than three times and occupied 13,000 ha in 2019. The average forest area per capita increased to 0.79 ha.

According to NFI (National Forest Inventory) data, since 2003 total growing stock volume increased from 453.4 million m^3 up to 552.8 million m^3. Pine stands accumulated growing stock of 228.1 million m^3. In a period of sixteen years they accumulated 48.1 million m^3. The growing stock in spruce stands increased from 75.8 to 98.1 million m^3.

The volume of birch stands increased by 8.4 million m^3 to 87.2 million m^3. The stocks of black alder have risen by 18.0 million m^3, reaching 55.7 million m^3. 36.8 million m^3 were accumulated in aspen stands and this volume practically is the same as sixteen years ago. The volume of grey alder stands remained at the same level (23.5 million m^3). Oak stands accumulated growing stock of 12.0 million m^3. Ash stocks decreased more than three times and were 2.6 million m^3 in 2019.

The average growing stock volume in all forests since 2003 increased by 34 m^3/ha up to 260 m^3/ha. The growing stock volume of mature stands in III-IV forest groups has increased from 109.9 to 153.7 million m^3 in average 2.7 million m^3 per year. The gross annual increment increased from 16.0 to 20.4 million m^3 in average and now contain 9.6 m^3/ha per year. The average growing stock volume per capita reached 198 m^3.

In the beginning of 2019, the distribution of forests by functional groups was as follows. Group I (strict nature reserves): 25,300 ha (1.2%); group II (ecosystem protection and recreational): 260,300 ha (11.8%); group III (protective): 288,200 ha (13.1%); and group IV (commercial): 1,623,300 ha (73.9%). Changes of forest land area distribution by forest groups are based on the decisions of forest management schemes.

By the 1st of January 2019, around half of all forest land in Lithuania was of State importance – 1104,700 ha. 857,000 ha of private forests were registered in the State Enterprise Centre of Registers. After intersection of layers of all forests and private holdings the estimated area of private forests was adjusted to 891,100 ha.

There were changes in managers of state forests in 2019. According to the order of Minister of Environment of the Republic of Lithuania, 2018 January 8th No. D1-7 all 42 State Forest Enterprises were reorganized by merging them with the state enterprise State Forest Management Institute. All property, rights and obligations of State Forest Enterprises were taken over by the State Enterprise State Forest Management Institute, which continued its operation under the name State Forest Enterprise. New enterprise manages 1,069,200 ha of forest land. Forests managed by the State Forest Enterprise were distributed among 26 regional subdivisions with mean area of 41,100 ha. The regional subdivisions are further divided to 338 districts; the number and average area (3,200 ha) of the districts has not changed during the year.

By the 1st of January 2019 the number of private forest owners amounted to almost 255,600, with a forest estate averaging 3.4 ha.

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

The total value added in the forest sector (including manufacture of furniture) reached EUR 1.8 billion in 2017. Total value added (at current prices) increased by 9% over the year. Sectors share in the total national value added was 4.6% in 2017, while in 2000 it was only 3.0%. The biggest share (EUR 826 million) of the value added in the sector was generated by the furniture industry, however the share of the furniture industry increased from 0.79% till 2.17% since 2000. The value added in the woodworking industry increased up to EUR 508 million. Its share in sector (1,34%) is increasing to a lower extent compared to the furniture industry. The increase of pulp and paper industry share in the total value added was more significant to the other industries. It amounted in EUR 217 million and 0.57% in total value added. Forestry and logging generated EUR 212 million of the value added. The share of this sector in total value added has remained almost unchanged since 2000. The increases and decreases are mainly related to the changes in roundwood prices.

Table 1. Share of forest sector in total value added

Year	*Gross value added, at current prices*								
	Total	***Forestry and logging***		***Manufacture of wood, products of wood and cork and manufacture of articles of straw and plaiting materials***		***Manufacture of pulp, paper and paper products***		***Manufacture of furniture***	
	Million EUR	***Million EUR***	***%***	***Million EUR***	***%***	***Million EUR***	***%***	***Million EUR***	***%***
2000	11 881	69,7	0,59	150,5	1,27	39,9	0,34	94,4	0,79
2001	12 635	70,0	0,55	175,0	1,39	47,3	0,37	107,5	0,85
2002	13 524	74,4	0,55	205,8	1,52	47,5	0,35	133,3	0,99
2003	14 937	79,5	0,53	243,5	1,63	48,5	0,32	162,9	1,09
2004	16 500	85,9	0,52	285,2	1,73	58,7	0,36	229,8	1,39
2005	19 010	94,6	0,50	321,6	1,69	60,7	0,32	252,1	1,33
2006	21 734	104,7	0,48	343,3	1,58	60,2	0,28	315,7	1,45
2007	26 077	146,1	0,56	392,6	1,51	67,3	0,26	359,9	1,38
2008	29 349	144,2	0,49	348,5	1,19	80,9	0,28	421,0	1,43
2009	24 300	100,4	0,41	274,7	1,13	72,4	0,30	333,9	1,37
2010	25 137	139,7	0,56	317,4	1,26	104,9	0,42	376,2	1,50
2011	28 119	162,8	0,58	373,9	1,33	125,2	0,45	511,2	1,82
2012	30 148	138,9	0,46	379,5	1,26	134,0	0,44	605,9	2,01
2013	31 715	174,5	0,55	424,3	1,34	162,4	0,51	648,2	2,04
2014	33 044	201,6	0,61	455,2	1,38	177,7	0,54	707,3	2,14

2015	33 604	149,6	0,45	463,9	1,38	177,7	0,53	735,2	2,19
2016	35 001	181,7	0,52	497,6	1,42	188,7	0,54	744,1	2,13
2017	37 975	211,5	0,56	508,1	1,34	216,5	0,57	825,8	2,17

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

The restrictions for clear-felling are constantly increasing in the legislation. Requirements to replace these fellings by non-clear fellings creates more possibilities to the forest regain naturally. Clear-cutting and human-inducedreforestation are particularly limited in the protected areas. These restrictions are foreseen to increase the share of naturally recovered forests and preserve the diversity of genes and the gene pools of local populations. The situation in state-owned forests and private forests is a bitdifferent. In state forests, about half of the clear-cut forests are restored by planting. Another 25 percent is reforested in a mixed way. In these areas deficient amount of naturally grown trees is supplemented with samplings grown in the nurseries. The situation is different in the private forests. About one third of the area after clear- fellings private forest owners restore by planting. Stakeholders keen to leave the significant part of the stands for the natural regeneration.

One of the aims of human-induced regeneration is to improve the economic potential of forests, using the more adaptive and higher selection value of FRM, which has been derived from approved units of FGR. Furthermore, FGR contribution is assumed as a prerequisite towards relevant Sustainable Development Goal. For this reason, the procedure for the collection of seeds is strictly regulated. All forest reproductive material for reforestation is allowed to collect exceptionally from the officially registered type of basic material.

FGR have an important role aiming for increasing forest productivity, stability and resistance to biotic and abiotic factors. FGR do not only increase forest resistance to climate change, with selection of the most stable and resistant forest populations to preserve. Stable and resistant forest stands, regenerated or planted using production from forest genetic resources, are not only resistant to climate change, but are also important for climate change mitigation. Productive forest stands ensure carbon sequestration in forest biomass and soil, significantly contributing to enhancing greenhouse gas removals in the country. The importance of greenhouse gas removal potential in forests is increasing in the future, taking into account the ambitious goal of the European Union to become climate neutral by 2050, meaning that greenhouse gas emissions cannot be higher than removals in the same territory.

Part 2: State of diversity in forest and woodlands

Chapter 2. State of forests

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Temperature and precipitation are two crucial drivers for forest ecosystems, therefore changes in both of these factors can have a significant impact for the condition of forest genetic resources as well. Therefore, climate change, resulting in changes of precipitation (droughts or heavy rainfalls), temperature and other climatic factors, such as storms, is threatening forest genetic resources the same as the whole forest land. Due to unfavourable climatic conditions, the frequency and intensity of various forest disturbances, such as insect or other pest outbreaks may increase in the future.

Chapter 3. State of other wooded lands

Other wooded land in Lithuania could be described as areas covered with woody vegetation, which are not compliant with the minimal requirements set for forest land (minimum area of 0.1 ha, 30 per cent of tree crown cover, tree height at maturity age – 5 m). Such areas are usually under agricultural land use category and can either be natural forest expansion with trees or areas temporary or permanently covered with bushes/shrubs. Areas of natural forest expansion are included in forest land area after the average age of the trees reaches 20 years, according to the Order of the Minister of Environment and Minister of Agriculture, No D1-409/3D-331, adopted on the 8th of May 2012. The above-mentioned order also sets the rules for the inventory of areas of natural forest expansion and explains that the age requirement of 20 years is not relevant when the inventory and inclusion the area to forest land is requested by the land owner.

According to the National Forest Inventory measurements from 2013 – 2018, the area of natural forest expansion (areas with woody vegetation not yet included under forest land category) has increased from nearly 59 thous. ha to 64 thous. ha, with most of the area being inventoried under grassland

category (according to the land use type definition used in the National Greenhouse Gas Inventory). The total growing stock volume in those areas has also increased significantly from 3.24 mill. m^3 in 2013 to 5.67 mill. m^3 in 2018. The increase in area of natural forest expansion and growing stock volume accumulated in those areas emphasise the importance of its contribution to the aim of increasing forest area coverage in the country as well as its climate change mitigation capacity. The compensational measure for the inventory of areas of natural forest expansion and inclusion of such areas under forest land category (inclusion in the State Forest Cadastre and the Real Property Cadastre and Register) is planned in the recently prepared National Energy and Climate Plan[1].

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

Forest Reproductive Material Regulation (2007) include 25 tree species which are considered as forest genetic resources: *Alnus incana* (L.) Moench, *Robinia pseudoacacia* L., *Quercus petraea* Liebl., *Tilia platyphyllos* Scop*., Larix decidua* Mill., *Larix kaempferi* (Lamb.) Carriere, *Alnus glutinosa* Gaertn., *Ulmus glabra* Huds. *Betula pendula* Roth, *Tilia cordata* Mill., *Quercus robur* L., *Fagus sylvatica* L., *Picea abies* Karst., *Ulmus laevis* Pall., *Acer platanoides* L., *Pinus sylvestris* L. *Ulmus minor* Mill., *Carpinus betulus* L., *Fraxinus excelsior* L., *Larix x eurolepis* Henry*, Betula pubescens* Ehrh., *Quercus rubra* L.; *Prunus avium* Moench, *Populus spp. (including Populus tremula and hybrid poplars)*
All 25 species are managed and utilized in the forestry (including agroforestry). Among them, 14 of the species are native, 4 are naturalised (*Quercus petraea*, *Fagus sylvatica*, *Larix decidua, Prunus avium*), 5 are introduced (*Robinia pseudoacacia*, *Tilia platyphyllos, Larix kaempferi*, *Larix x eurolepis* Henry, *Populus spp).*

There are no new forestry species being registered for use, but an extent of planting of mentioned 3 naturalized and 5 introduced tree species has a tendency to increase, especially *Quercus petraea*, *Fagus sylvatica* L., *Larix decidua, Prunus avium and Populus spp*. Many tree species have been planted in parks and arboretums (about 800, including varieties) and their number tend to increase due to a lesser losses as harsh winters are less frequent due to global climate change.

The main of the threatened species is *Fraxinus excelsior* because of the outbreak of ash dieback, caused by fungus *Hymenoscyphus fraxineus and in some cases Picea abies Karst due to the damages caused by bark beetle.* Some species may be introduced by stakeholders (eg. Oxytree) without scientific recommendations and state control (if it is not intended to use for forestry purpose), but, while such species are in the registered species list, it not possible to get subsidies. This diminishes interest in planting such species. Harsh winter conditions also reduce survivability of non-recommended introduced species. Number of tree species in urban greenery, parks, arboretums and in private households tend to increase as people enjoy having beautiful greenery and new ornamental species and varieties.

[1] The National Energy and Climate Plan of Lithuania (in Lithuanian), https://am.lrv.lt/uploads/am/documents/files/KLIMATO%20KAITA/Integruotas%20planas/Final%20NECP.pdf

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

Forestry sector and society in general are well informed about the importance of genetic diversity in reforestation/afforestation. Seeds for the growing of forest reproductive material are collected in country-wide network of registered seed stands and forest stands of decent genetic quality which cover variety of sites having sufficient effective population in size and mast years only. Seeds for the growing of forest reproductive material are also collected in country-wide network of seed orchards, which have sufficient number of clones, originating from different populations, which results in good gene recombination and genetic diversity. Rather large density of requested self-regeneration and planting (under control of State Forest Service) also contributes to sufficient genetic diversity of new generation.

Recent genetic studies using DNA microsatellites (eg. Verbylaitė et al., 2019, Sirgedienė, 2020) in self-regenerating stands of main tree species showed no reduction of genetic diversity in comparison to neighboring mature stands.

Pilot studies on monitoring of forest genetic diversity using DNA microsatellite technology were recently started in order to launch a routine long-term monitoring of genetic diversity in forest genetic reserves and seed stands as well as in regenerating areas and forest plantations.

Two biotechnology laboratories (in the LRCAF (Institute of Forestry) and in Vytautas Magnus university Agriculture Academy) are involved in genetic research and development of forest genetics monitoring. New well educated and internationally trained staff is already available (5 PhD graduates) although allocation of specially-aimed financial resources are urgently needed.

Part 3: State of forest genetic resources conservation

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

In situ forest genetic resource units comprise 0.25 % from total forest area of the country. There is a wide network of specially designated forest genetic reserves of all forest tree species, covering all provenance regions of the country. These forest genetic reserves are registered and documented as protected areas. Some forest genetic reserves which are within other types of reserves (e.g. botanical reserves) are registered as genetic stands. All in situ gene conservation areas - genetic reserves, genetic stands and seed stands are also registered in the Register of Lithuanian Forest Seed Sources. Number of genetic reserves of some tree species is a surplus and therefore should be optimized by reduction in number and concentrating on proactive conservation efforts in most suitable and representable stands, designating them as in situ gene conservation populations.

Forest genetic reserves are designated to preserve and conserve genetic diversity of a species over environmentally heterogeneous sites on comparatively small areas (3-150 ha). The main conservation efforts were placed on *Pinus sylvestris* and *Picea abies*, but there are also genetic reserves established for many other tree species listed in Chapter 4. Gene conservation in designated forest genetic reserves in Lithuania is based on principles of MPBS which have been recommended by EUFORGEN and is done

by applying dynamic gene conservation measures. Genetic reserves are representing both typical and specific sites to cover wide spectrum of existing adaptations. Another key element is that each genetic reserve should be sufficiently large effective population in size to guarantee sufficient genetic diversity and avoid inbreeding and genetic drift. Sanitary felling is obligatory to avoid spread of diseases and insects. Many efforts are devoted to promote natural regeneration and create a multi-aged patchy stand structure in each forest genetic reserve thus enhancing sustainability and longevity of forest ecosystem and guarantee sustainable gene conservation.
Conservation of forest genetic resources within other types of protected areas, such as Nature reserves or NATURA 2000 Habitats is facing problems as not all gene conservation measures are allowed to be performed in most EC Habitats. Therefore, it is requested to avoid overlapping of new planned protected areas with already existing forest genetic reserves.

There are four main players involved in organization of in situ conservation. The procedure of the establishment and management of forest genetic units can be described as follows:
The experts from Lithuanian Research Centre for Agriculture and Forestry, Institute of Forestry, State Forests Enterprise, Vytautas Magnus University Agriculture Academy can recommend the objects for the inclusion to the *in situ* conservation database. Lithuanian State Forest Service makes an assessment, takes the final decision and provides the needed documentation. Lithuanian State Forest Service includes *in situ* conservation units to the database and issues their passports. Management of *in situ* conservation units is provided by the State Forest Enterprise and supervised by Lithuanian State Forest Service. The applied measures in the objects are being planned by State Forest Service. The list of forest genetic resources units is provided in the Lithuanian Forest Seed Base with annual update. State Forest Service is responsible for the compilation of this list and annually displays it on the official website. The shortened version of this data - the National List of FGR is sent to FOREMATIS (forest reproductive material information system), managed by the European Commission. In addition to this, the Service of Protected Areas which is within the Ministry of Environment, is responsible for all types of national protected areas, including forest genetic reserves. It co-ordinates and sets financing for new forest genetic reserves, including their documenting and registering. The monitoring and management of genetic reserves are organized by State Forest Service, while practical measures on promoting regeneration, sanitary protection and seed collection is done by the State Forest Enterprise.
The Program for conservation of forest genetic resources and tree breeding was adopted in 2003 for 10 years period and was implemented during 2004-2014. New Program for conservation of forest genetic resources and tree breeding was developed in 2015 by the researchers of Vytautas Magnus University Agriculture Academy and Lithuanian Research Centre for Agriculture and Forestry.

Implementation of new Program for conservation of forest genetic resources and tree breeding that was developed in 2015 is progressing too slowly.
Most challenging situation is with undergoing expansion in areas of Nature reserves and NATURA 2000 habitats that often overlap with existing forest genetic reserves thus preventing from applying measures for proactive gene conservation and ruining well organized and functioning national dynamic

forest gene conservation system. It is of great importance to establish monitoring system to periodically monitor DNA genetic diversity in genetic reserves, including their mature and regenerating parts.
In order to successfully implement new Program for conservation of forest genetic resources and tree breeding, which was developed in 2015, establishment of Genetic monitoring laboratory should be considered under State Forest Service or long-term contracts should be set with LRCAF or Vytautas Magnus University (which already have DNA laboratories) for continuous monitoring of forest genetic reserves of all forest tree species. Permanent funds should be allocated/granted for such genetic monitoring.

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

Ex situ conservation is supplementary to in situ conservation. Ex situ conservation is done in network of progeny trials, provenance/population trials, clonal collections, and in seed banks of National Plant Gene Bank and Forest Tree Gene Bank.

Series of progeny trials were established since 1983 in different provenance regions (under different adaptive environments) and serve both for tree breeding and ex situ conservation purposes. They each accumulate national-wide material of each tree species: half-sib progeny from plus trees and from in-situ gene reserves, seed stands and tested populations. Series of provenance/population trials were established before 1983 in different provenance regions under different adaptive environments and also serve as ex situ gene conservation populations. Clonal archives is a parallel measure for ex situ gene conservation and accumulates national-wide grafted material from plus trees. One clonal archive is established for each tree species, that is of higher importance in the industry. The total number of clonal collections is 18, occupying 57.47 ha area. Seed collections in National Plant Gene Bank and Forest Tree Gene Bank are supplementary measures *for ex situ* collections.

Collections in seed banks of National Plant Gene Bank and Forest Tree Gene Banks are still not completed for each tree species while some already need a renovation (eg. *Fraxinus excelsior, Betula pendula*). A cryogenic storage of in vitro cultures are planned to be developed for conservation of recalcitrant tree species. There are plans to merge National Plant Gene Bank and Forest Tree Gene Bank.

In order to successfully implement the new Program for conservation of forest genetic resources and tree breeding (2015), genetic diversity testing/monitoring should be established in addition to seed vitality testing/monitoring to secure full-fledged and sustainable *ex situ* conservation of forest genetic resources.

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

Chapter 8. The state of use

It is officially agreed that the system of Lithuania's forest genetic resources management/protection(?) fulfils demand, which encompasses both protecting FRG and breeding purposes in the country. The units for forest genetic conservation covers around 1 % from the total area of premature and mature stands. The number of genetic reserve units is 162 (total area of 3 726 ha), seed stands - 189 (total area of 15 150 ha), seed orchards - 185 (area of 925.8 ha).

National Forestry Sector Development Program for 2012-2020, approved by resolution No. 569 of the Government of the Republic of Lithuania of 23 May 2012, is still in force, and as a part of it, the planning of activity and/or(?) measures for Protecting and Development of Forest Genetic Resources for 2018-2020 is under way, which aims for actual measures for R&D and implementing of practical tasks. In addition to this, the new Program for conservation of forest genetic resources and tree breeding was approved (2015), created by experts from Vytautas Magnus university Agriculture Academy and LRCAF (Lithuanian Research Centre for Agriculture and Forestry, Institute of Forestry).

Seed orchards play an important role in the supply of FRM: for coniferous trees it reaches around 70 % and for broadleaves 30 % of total FRM production in the country. Seed stands play a minor role here, especially for coniferous production.

Over the last 5-7 years there were no lack of FRM production in the country. The biggest part of imported plants are aspen hybrids from Latvia and Estonia. Import of FRM is mostly related with the support-foundation of EU, which is triggered by the Program of afforestation of abandoned areas or areas not suitable for agricultural purposes.

The export of FRM reached around 5.8 million and import decreased up to 0.3 million of plants during the last few years.

FRM, which is produced and traded for multifunctional forestry outside and within country is covered in 100 % by Master Certificates of Origin, issued by official designed authority - State Forest Service. This is the obligation, which is stated for private and state forest owners and guided by the Regulation on Forest Reproductive Material.

In general, the use of forest genetic resources meets decent attitude of the Ministry of Environment and Government, therefore no obstacles for the conservation and sustainable management of FRG is foreseen in the future. However, the question of the establishment of new FGR units in private forest holdings is still open and needs further efforts for dissemination of knowledge, awareness and laying down the legislative tools for compensation of the restricted management of FGR in such holdings.

State Forest Enterprise, which deals with forest nurseries, few years ago started the optimization of its infrastructure. The quantity of State Forest nurseries was reduced from 37 up to 14 modern nurseries, (two of them are using the last technology of containers, greenhouses and polygons). The annual production reaches around 45 million of shipping plants.

Chapter 9. The state of genetic improvement and breeding programmes

Tree breeding in Lithuania is done based on Program for conservation of forest genetic resources and tree breeding that was adopted in 2003 for 10 years period and was implemented during 2004-2014. New program for conservation of forest genetic resources and tree breeding was developed in 2015 and is now being implemented. The program is based on recurrent multiple-population multi-cycle breeding principle. The program describes number of breeding populations, crossing and testing schemes separately for each forest tree species. High intensity tree breeding is designed for *Pinus sylvestris, Picea abies, Quercus robur, Betula pendula* and *Populus spp*. while low intensity tree breeding is designed for *Fraxinus excelsior, Alnus glutinosa, Ulmus spec.,*etc. For *Pinus sylvestris, Picea abies, Quercus robur,* and *Betula pendula* 4-5 breeding subpopulations per tree species will be established, 1-2 per each provenance region of the species. Each breeding subpopulation consists of 50 best genotypes selected in half-sib progeny trials under previous Tree breeding program. In the first cycle 50 individuals will be crossed within subpopulation by applying double-pair mating principle and resulting in 50 full-sib families which will be tested in progeny trials. For *Picea abies, Fraxinus excelsior* and *Populus spp*, obtained juveniles will be vegetatively propagated and clonal trials established. In addition an elite-lines approach will be used for *Picea abies*.

Forest tree breeding results are practically implemented through seed orchards. Diversified breeding strategies with the focus on resistance to pathogens and wood properties improvement is under implementation. Complex selection index includes total height, diameter, stem straightness, branch angle or thickness, spike knots, survival or resistance (in case of *Pinus sylvestris*, *Fraxinus excelsior* and *Ulmus* species) and wood hardness. The main aim is to increase disease resistance while avoiding losses of growth and stem quality.

There are two types of organizations included in treebreeding:

1. Lithuanian Research Centre for Agriculture and Forestry initiates and prepares the long-term breeding Programmes, which, after the assessment by Advisory Group of Experts for R&D of FRG (AGE), are approved at the Ministry of Environment. Lithuanian State Forest Service and State Forest Enterprise are responsible for the implementation of planned measures to the practice.

2. Tree breeding is organized by the Ministry of Environment and State Forest Service and is based on short-term (2-3 years) specially aimed contracts with tree breeders from LRCAF (Institute of Forestry) and Vytautas Magnus University Agriculture Academy in cooperation with State Forest Enterprise for accomplishing separate tasks of tree breeding program such as measurement and selection of individuals for crossing, performance of crossings, vegetative propagation, establishing progeny trials, etc.

In vitro propagation technologies should be used for production of clones for crossings and for mass production of improved reproductive material of *Picea abies, Fraxinus excelsior* and *Populus spp.* DNA genetic diversity monitoring should be used to monitor co-ancestry and genetic diversity in breeding sub-populations and elite lines. Newly developed very efficient methods of IR spectroscopy of tree bark

phenols (Villari et al. 2018) may be used for phenotyping and identifying disease resistant individuals in breeding populations of *Fraxinus excelsior.*

The priority should be given for long-term contracts, as the forest tree breeding is a long-term continuous process, while a present organization, which is based on short-term contract, is less sustainable and efficient. As an option, an establishment of permanent Forest tree breeding center/department/sector in LRCAF, which would facilitate more successful full scale and timely implementation of Tree breeding program, could be considered.

Crossing facilities (greenhouses, pollen processing rooms, etc.) are under designing and should be built in 2-3 years as an infrastructure of State Forest Enterprise.

Chapter 10. Management of forest genetic resources

Management of forest genetic resources in natural and planted forests is provided by the State Forest Enterprise and controlled by Lithuanian State Forest Service. The applied measures in the objects are planned by State Forest Service. Methodological recommendations are prepared by the Lithuanian Research Centre for Agriculture and Forestry, Institute of Forestry.

Further development of forest genetic resources network of objects is constrained by the increase of protected and private forest area (privatization of areas, which are reserved for restitution).

There is a need of long-term projects and financed programs for management of forest genetic resources, as well as for tree breeding.

Involvement of scientists to international projects and adoption of recommendations issued and approved by International Institutions would facilitate the progress. Integration of country forest genetic resources network to European network and application of recommendations from international experts would promote progress in this research area.

Part 5: State of capacities and polices

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

Forest genetic resources in Lithuania are divided into 2 groups due to their importance: national (higher status) and ordinary. Permanent Plant National Genetic Resources Board decides which genetic units have to be included to National Genetic Resources List. Plant Gene Bank (recently incorporated to Lithuanian State Forest Service) staff acts as a coordinator for plant genetic resources (PGR) coordination centres: agricultural crops, forest trees, horticultural crops, ornamental plants, medicinal and aromatic plants. Plant Gene Bank and Lithuanian State Forest Service manage the separate databases on forest genetic resources, the first one only on national level. Each forest genetic resource unit has a passport, issued by Lithuanian State Forest Service, which also controls and reports the status of all units. The list of forest genetic resources objects is provided in the Lithuanian Forest Seed Base

with annual update. State Forest Service is responsible for providing this information. Both institutions run long-term seed storage, which will be merged in July 2020.

As it was mentioned before, three main institutions are involved practically in official management of forest genetic resources: State Forest Service, State Service for Protected Areas under Ministry of Environment (SSPA) and State Forest Enterprise. State Forest Service provide legal basis for the assessment, establishment, approval and preparation of special measures for conservation of FGR. State Service of protected Areas is responsible for registration, preservation and management of protected areas not only in forest land, but also covering other land uses.

Thus, in some FGR units a double protective purpose may be observed, due to its assignment to the other protected areas and this situation impede finding of balanced measures and solutions while choosing different approaches and protection goals for targeted FRG units. The State Forest Enterprise is directly responsible for the implementation of recommendations and all practical activity in their domain. It is important, that no FGR units are established in the privately owned forest land.

Legislation and regulations, related to forest genetic resources are as follows:

- The Forest Law of the Republic of Lithuania
- Law on National Plant Genetic Resources of Lithuanian Republic
- Law on Protected areas of the Republic of Lithuania
- Regulation on Natural and Complex Preserves
- Regulation on Forest Reproductive Material
- Rules for Forest Cutting
- Regulation on Forest Genetic Resources Information System
- The methods presume for Selection of Forest Genetic Recourses

Lithuanian Research Centre for Agriculture and Forestry is granted a right for doctoral studies in Agronomy and Forestry as well as Ecology and Environmental Sciences jointly with Vytautas Magnus University. The doctoral studies provided by the Centre conform to the contemporary problematics of forestry sciences, up-to-date methods and facilities used in researches. Studies and researches are headed by experienced researchers. Lithuanian Research Centre for Agriculture and Forestry provides the opportunity for study visits to foreign countries.

Lithuanian State Forest Service organizes regional seminars for state and private forest owners each year. In that way the dissemination of the newest knowledge on management of FGR is fulfilled. All seminars serve as practical actions and Lithuanian Research Centre for Agriculture and Forestry, Institute of Forestry has the project-based responsibility to establish demonstration-educational field trials. Organization of seminars for PhD students, State Forest Enterprise staff and private forest owners is also one of the responsibilities of Institute of Forestry together with scientists from Vytautas Magnus University Agriculture Academy.

Lithuanian Research Centre for Agriculture and Forestry, Institute of Forestry, together with Vytautas Magnus University Agriculture Academy used to run joint scientific projects. This enables efficient use of laboratory equipment and infrastructure.

The use of cross sectoral (together with the Centre for Physical and Technological Sciences, Lithuanian Energy Institute) cooperation can provide new advantages and possibilities. Participation in European Green Deal policy initiatives is one of the possible platforms for it.

Chapter 12. International and regional cooperation on forest genetic resources

Researchers and tree breeders from LRCAF and Vytautas Magnus University Agriculture Academy are involved in many International and regional projects on studies and conservation of forest genetic resources and tree breeding:
COST Action CA18134 "G-BIKE - Genomic BIodiversity Knowledge for Resilient Ecosystems" (2019-2023);
International project 'Ash-Adapt - Evolutionary potential of natural *Fraxinus excelsior* populations challenged by novel pests and pathogens' GWAS, (2019-2021, Denmark, Austria, Sweden, Germany);
SNS Nordic Forest Research international project 'Production of ash cuttings to increase efficiency of breeding activities to maintain full range of ecosystem services provided by this keynote species' (2019-2020, partners Sweden, Ireland, Denmark, Norway, USA);
SNS Nordic Forest Research international project 'Conservation of resistant ash (*Fraxinus excelsior*) genotypes in Nordic and Baltic regions to maintain the full range of ecosystem-services provided by this keystone species' (2019-2022, partners Denmark, Finland, Norway, Sweden);
International project 'Long Term Forest Research CoFoRD Programme: WP3 – FORM – Forest Management – Research required to investigate genetic resistance to ash dieback disease *Hymenoscyphus pseudoalbidus* (anamorph *Chalara fraxinea*) and the development of disease resistant ash planting stock' (2016-2020, partners: Ireland, France and UK);
COST Action FP1103 'FRAXBACK – *Fraxinus* dieback in Europe: elaborating guidelines and strategies for sustainable management' (2012-2016).
Lithuania is EUFORGEN (European Forest Genetic Resources Conservation Program) member country since 1994. The scientists from Lithuanian Research Centre for Agriculture and Forestry, Institute of Forestry, and Vytautas Magnus University Agriculture Academy are participating in different COST Actions dealing with forest genetic resources. There were some international projects including both conservation of genetic resources and breeding (e.g. ”Estimation of Scots pine ecological plasticity using molecular-genetic methods aimed to improve reforestation strategy in the context of climate change, to preserve forest biodiversity and genetic resources in Belarus and Lithuania“, “Ash-Adapt – Evolutionary potential of natural *Fraxinus excelsior* populations challenged by novel pests and pathogens“, “Optimising the management and sustainable use of forest genetic resources in Europe”). The main focus of the studies or activity in such projects was on evaluation of population polymorphism in phenotypic-genotypic traits associated with the polymorphism of molecular markers, investigation

of the postglacial migration of tree species, population genetic variation and adaptation studies, forest tree breeding with the aim to increase general and specific resistance of selected material. Being a member of EUFORGEN Lithuania participates in actions initiated by the organization, provides the necessary information for EUFGIS information system.

State Forest Service is also a member of Forest Genetic Network (FGN), which actually aims for practical approaches of managing the FGR. Members of this network are the experts from different European countries, dealing with the protection of FGR.

The new methods of genetic monitoring are under adaptation based on EUFORGEN guidelines and recommendations. New approaches to increase general and specific resistance in Scots pine, common ash and Norway spruce are under implementation. There are series of field trials established in cooperation and using material from European countries, with special focus to information/material(?) from Poland and Latvia. Population progenies from our country are included in the experiments in other European countries.

International efforts are needed to tackle the problems that bring some non-native pathogens. There is a need to put more efforts on applied science and the output implementation to practical forestry.

Part 6: Challenges and opportunities

Chapter 13. Recommended actions for the future

The list of objects of the Lithuanian Forest Seed Base (including all FGR) with annual update is officially displayed on the website of Lithuanian State Forest Service and is free for public use.

The project on preparation of methodology for genetic monitoring of Scots pine, Norway spruce, common oak and silver birch has started in Lithuania. There is also a need to include more species to genetic monitoring system. Detailed investigation on genetic diversity and plasticity of species would help to optimize the network of genetic units.

 Use, development and management of forest genetic resources

The recommendations on optimization and potential of Scots pine gene reserves for conservation and enhancing genetic resources were prepared for forestry sector. Revision of the main forest tree species provenance regions based on DNA and, if possible, field trial experiments data analysis was done.

Institutions that are involved in use, development and management of forest genetic resources (not listed by the importance) are: 1) Lithuanian Research Centre for Agriculture and Forestry, Institute of Forestry; 2) State Forest Enterprise; 3) Lithuanian State Forest Service; 3) Vytautas Magnus University Agriculture Academy; 4) Nature protection and Forest policy division at the Ministry of Environment of the Republic of Lithuania, 5) Plant Gene Bank (will be incorporated in State Forest Service in July 2020).

References

National Forestry Sector Development Program for 2012-2020, approved by resolution No. 569 of the Government of the Republic of Lithuania of 23 May 2012.

National Environmental Protection Strategy, 2016 ISBN 978-609-8081-6

Lithuanian Statistical Yearbook of Forestry, 2019, State Forest Service

The National Energy and Climate Plan of Lithuania (in Lithuanian), https://am.lrv.lt/uploads/am/documents/files/KLIMATO%20KAITA/Integruotas%20planas/Final%20NECP.pdf