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

COUNTRY REPORT

SERBIA

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.

Republic of Serbia
MINISTRY OF AGRICULTURE,
FORESTRY AND WATER MANAGEMENT

UNIVERSITY OF BELGRADE
FACULTY OF FORESTRY

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

SERBIA

Authors

Mirjana Šijačić-Nikolić
Jelena Milovanović
Marina Nonić
Vladan Ivetić
Vladan Popović
Aleksandar Lučić

JUNE, 2020

Preface

The report on the state of forest genetic resources in Serbia was created for the purposes of drafting the Second Report on the State of Forest Genetic Resources of the Food and Agriculture Organization of the United States (FAO).

The first report on the state of forest genetic resources in the world was made in 2014 and represented a turning point in development the database and knowledge needed to act at the national, regional, and international levels. The report is based on reports from 86 countries that represent over 85% of the global forest cover. The report concluded that about half of the forest species in the reporting countries are endangered or susceptible to genetic erosion. Serbia did not participate in the preparation of the first report.

In July 2019, the FAO invited countries to update the nominations for the national coordinators for forest genetic resources and submit reports on the state of forest genetic resources in their countries which will serve as a basis for the Second Report on the State of Forest Genetic Resources, the first version of which is planned for 2022.

In September 2019, the Forest Directorate of the Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia entrusted the preparation of the Report on the state of forest genetic resources in Serbia to the University of Belgrade – Faculty of Forestry.

The following researchers participated in the preparation of the Report:

1. prof. Mirjana Šijačić-Nikolić, PhD, University of Belgrade – Faculty of Forestry, project manager,
2. prof. Jelena Milovanović, PhD, Singidunum University – Environment and Sustainable Development,
3. asst. prof. Marina Nonić, PhD, University of Belgrade – Faculty of Forestry,
4. assoc. prof. Vladan Ivetić, PhD, University of Belgrade – Faculty of Forestry,
5. Vladan Popović, PhD, senior research associate, Institute of Forestry, Belgrade
6. Aleksandar Lučić, PhD, senior research associate, Institute of Forestry, Belgrade.

The report is written following the recommended structure and contains 13 mandatory chapters, used literature sources, and annexes. It provides an overview of the state of forest genetic resources in Serbia from various aspects, as well as recommended activities for improving the state of priorities. It is written in Serbian and English.

Acknowledgments

The researchers of the team for the preparation of the Report express gratitude to the Directorate of Forests of the Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia for the indicated trust and the entrusted work.

CONTENTS

ABBREVIATIONS AND ACRONYMS

AMOVA	Analysis of Molecular Variance
AP	Autonomous Province
CBD	Convention on Biological Diversity
CEEPUS	Central European Exchange Programme for University Studies
CITES	Convention on International Trade in Endangered Species of Wild Flora and Fauna
CLRTAP	Convention on Long-range Transboundary Air Pollution
CONVERGES	Knowledge conversion for enhancing management of European riparian ecosystems and services
DOF	Directorate of Forests
ECPGR	European Cooperative Programme for Plant Genetic Resources
EFI	European Forest Institute
EU	European Union
EUFORGEN	European Forest Genetic Resources Program
FA	Forest Administration
FAO	Food and Agriculture Organisation of the United Nations
FD	Forest Directorate
FE	Forest Estate
FGR	Forest Genetic Resources
FMU	Forest Management Unit
FP 7	7th Framework Programme for Research and Technological Development
FRA	Forest Resources Assessment
FSC	Forest Stewardship Council
G-BIKE	Genomic Biodiversity Knowledge for Resilient Ecosystems
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GenRes Bridge	Genetic resources for forested and food-secure Europe
GMO	Genetically Modified Organism
GTZ	German Organization for Technical Cooperation
HNVF	High Nature Value farming
IPA	Important Plant Area
IPA (funds)	Instrument for Pre-Accession Assistance
IUCN	International Union for Conservation of Nature
IUFRO	International Union of Forest Research Organizations
LIFEGENMON	Life for European Forest Genetic Monitoring System
MCPFE	Resolutions of the Ministerial Conference on the Protection of Forests in Europe
MPBS	Multiple Population Breeding System
NFI	National Forest Inventory of Republic of Serbia
NGOs	Non-governmental Organizations
NP	National Park
NWFP	Non-Wood Forest Products
OECD	Organization for Economic Co-operation and Development
OG	Official Gazette
OWLs	Other Wooded Lands
PE	Public Enterprise
REC	Regional Environmental Center for Central and Eastern Europe
SSRs	Simple Sequence Repeats
STSMs	Short Time Scientific Missions
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WWF	World Wildlife Fund

EXECUTIVE SUMMARY

Forest Genetic Resources (FGR) provide a wide range of products and services to people in Serbia. The most important forest products recognized by local communities in Serbia are timber (firewood), widespread forest fruits and other edible plants, mushrooms, medicinal and aromatic plants („wild fruits"). The poor availability of data in Serbia makes it very difficult to define and describe all FGR socio-economic functions and benefits for local communities such as carbon sequestration, protection of watercourses, recreation, and conservation of biodiversity, especially on the genetic level. The variety of experiences and perceptions of FGR benefits in Serbia requires *species-specific approach to forest management* through the implementation of conservation methods.

Serbia is considered to be a middle-forested country with a forest cover rate of 29,1% (a total of 2.252.400 ha). Even with a positive annual change rate, the national forest cover percentage is undesirable compared to an optimal level of 41.4 percent defined in the National Spatial Plan. Distribution of forest cover over the Republic's territory is uneven and there is a large proportion of coppice forests (64,7%), with low annual increment and unfavorable age structure. The main causes of the forest cover loss in some districts is illegal logging, as well as unplanned logging associated with intensified dying of forests, due to the occurrence of extreme events, fire, and attacks by pests and diseases.

According to the National Forest Inventory (NFI, 2008 - there is no more recent data because new forest inventory is in progress), other wooded lands (OWLs), including bushes and shrubs, cover a total of 382.400 ha, or 4,9% of the territory of Serbia. Some drivers affect the change in surface area and condition of OWLs in Serbia. These drivers can be categorized into two groups: a) *drivers that cause an increase of OWLs area*: illegal logging and overexploitation, habitat loss and fragmentation, forest fires, natural disasters, High Nature Value farming (HNVF) and climate change*;* and b) *drivers that cause a decrease of OWLs area*: adequate natural regeneration of forest sites, the first afforestation of OWLs, controlled application of HNVFs and site restoration.

Serbia is one of six biodiversity centers in Europe and one of 153 world biodiversity centers. In Serbia, 287 species of plants are endemic to the Balkans, accounting for 8.06% of Serbia's flora. The forest ecosystems are composed of about 250 native woody species and the presence of 88 wild woody fruit species is of particular importance for forest genetic resources. In addition to 250 indigenous tree species, a significant number of exotic (introduced species) are present in the forest fund of the Republic of Serbia. Of the species introduced, black locust (*Robinia pseudoacacia* L.) is the most prevalent, with a share of 10.3% in the total number of trees, followed by different poplar clones and cultivars.

Trends in the number of species in the forest fund of the Republic of Serbia will only be possible to evaluate after the completion of a new forest inventory, which is ongoing, after which it will be possible to compare the current numbers of individual species with those in the past (last state in 2007). What is evident is that negative activities in the recent and distant past have caused major changes in natural ecosystems, which have gradually led to the disappearance or decline of certain species of trees and shrubs, and their habitats have been destroyed or reduced to extremely small areas. According to data from 2009, in the forest fund of the Republic of Serbia, 12 species are marked as rare and endangered, 5 as rare, 9 as relic, 6 as endemic, and 6 at risk.

Assessment of intraspecific variability of forest trees in Serbia, using genetic markers, was performed for the most economically important species such as beech (*Fagus sylvatica* L.), sessile oak (*Quercus petraea* (Matt.) Liebl.), Scots pine (*Pinus sylvestris* L.), and Austrian pine (*Pinus nigra* J.F. Arnold), primarily to define the regions of provenance. Intraspecific variability studies have also been performed on species that are significant in terms of conservation and direct use of the available gene pool, such as wild cherry (*Prunus avium* L.), Serbian spruce (*Picea omorika* (Pančˇ) Purkyne) and black poplar (*Populus nigra* L.).

The studies conducted were performed at the test or maternal tree level representatives of population and their offspring in early tests established in a nursery or the field. Genetic variability of tree species in Serbia has been studied for a relatively small number of species, at partial portions of their distribution, and the research conducted does not have a continuous character to be able to assess for sure the variability trends for most of them. The trend of variability for beech (*Fagus sylvatica* L.) is the best studied. Research has been continuous for recent decades. Based on the results of the conducted research, it can be concluded that there is a satisfactory degree of genetic variability of this species, which can be characterized as stable but under significant pressure of climate change, which is also the case with other native species of trees. The decline of genetic diversity can be noted for some species that are characterized as relict, endemic, rare and/or endangered in the forest fund of the Republic of Serbia.

In situ conservation is most often applied in Serbia in natural populations which are naturally regenerated in protected areas and in forests that are regularly managed. Conservation of FGR in forests managed on a regular basis is mainly realised through designating seed facilities (seed stands, groups of trees, or individual trees). Conservation of forest genetic resources in forests is mainly realised through designating seed facilities (seed stands, groups of trees or individual trees). This form of FGR conservation is most frequently the only sustainable form since the financial resources allocated for conservation are modest. Currently, the area of protected areas is 677,950 ha, i.e. 7.66% of the territory of Serbia. There are 469 protected areas. To ensure the proper use of seeds from seed stands, decisions on establishing regions of provenance for the following forest tree species were issued: beech (5, redefined to 3), sessile oak (2) and common oak (2), Austrian pine (3), Scots pine (2), narrow-leafed ash (2), spruce (3) and fir (3). For all other forest tree species, the whole territory of the Republic of Serbia represents one region of provenance. 139 seed facilities of autochthonous forest tree species have been singled out in Serbia in the total area of 1443.7 ha, 37 of which are seed facilities of coniferous trees, 100 are seed facilities of broadleaved species and 2 mixed seed stands. The current number and area of seed stands are insufficient and do not reflect the abundance of gene pool of our country's forest tree species, to which special attention should be paid in the coming period.

Ex situ conservation of forest genetic resources in Serbia has been based on the conservation of individuals or groups of individuals by establishing field plantations. Conservation of forest genetic resources through the preservation of certain parts of individuals has not been performed in Serbia and there is no specialized gene bank for woody species. One of the most important approaches to *ex situ* conservation of forest genetic resources is establishing seed orchards.

To date, 10 special-purpose objects have been established in Serbia, for transformation into seed orchards and its registration: 2 vegetative objects of pedunculate oak (*Quercus robur* L.) and 2 of wild cherry (*Prunus avium* L.); 1 generative object of: pedunculate oak (*Quercus robur* L.), Balkan maple (*Acer heldreichii* Orph.), Serbian spruce (*Picea omorika* (Pančić) Purk.), Austrian pine (*Pinus nigra* Arn.), Scots pine (*Pinus sylvestris* L.), and narrow-leafed ash (*Fraxinus angustifolia* Vahl). From these objects, so far, only 3 received the status of registered seed orchards, as follows: 1 of Serbian spruce (*Picea omorika* (Pančić) Purk.) at 2.7 ha and 2 of pedunculate oak (*Quercus robur* L.) in a total area of 16.81 ha.

Several provenance trials have been established in Serbia until present: 3 provenance trials of Norway spruce (*Picea abies* /L./Karst.), 2 of Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) and 2 of beech (*Fagus* sp.). One of the forms of *ex situ* conservation in Serbia are clonal archives, living archives and genetic collections. On the sample plot of the Institute of Lowland Forestry and Environment, there are clonal archives of poplar, willow, and black locust. In Lipovica Scientific Research Station of the Institute of Forestry there is a living archive of forest fruit trees. The genetic collection of wild cherry has been established in the area of Forest Estate Sremska Mitrovica of the Public Enterprise „Vojvodinašume".

The use of FGR is well defined by legislative, although the Law on reproductive material of forest trees and some by-laws need improvements. The production of forest reproductive material is way below the needs, considering the strategic and operational management plans accepted. The frequency of masting years and years of full seed crop is disturbed and for some species (e.g. beech) there is a lack of seed material. The quality of seed collected in years between the full seed crop is poor and seedling rarely meets the quality standards. In the last five years, there was no import of forest reproductive material and export was symbolic. Only the seed of *Picea omorika* (Pančić) Purk. from seed orchards, was exported.

Up to date, different approaches have been taken in tree breeding, depending on the specific species. Since 1980, as a result of breeding programs, the Institute for Lowland Forestry and Environment has registered a number of willow and poplar varieties. Poplar breeding was performed on: drought stress, disease resistance, growth rate, a predilection for insects, tree properties, and the ability for phytoremediation. Registered willow varieties have better growth and volume increase, are more resistant to plant diseases and harmful insects, and adapted to cultivation on different types of soil. Breeding activities have been carried out with other tree species: Serbian spruce, sycamore, lime, bald cypress, European hop-hornbeam, beech, narrow-leafed ash, pedunculate oak, mainly at the level of scientific research or small projects.

Protected forest species, reproductive material, seed management, and forest genetic resources are taken in different contexts into account in the Serbian forestry planning documents, but the way of their management is not defined. The management plans, which are adopted for a period of 10 years, contain the state of the protected parts of nature, which includes the listing of plant species having the character of natural rarities, which can be considered as the basis for the management of FGR of relict, endemic, rare and endangered species of forest trees and shrubs.

The latest forest inventory of the Republic of Serbia (2020) will provide the possibility of controlling the number and analysis of the spatial distribution of trees from the above categories for the purpose of conservation. The selection of native tree species, with particular emphasis on climate-smart approach to afforestation is defined as the main priority in FGR management.

There is an insufficient commitment to the category of FGR, since, in Serbia, there are still no adequate, legally binding, legislative frameworks directly related to this field. The National program for conservation and sustainable utilization of FGR of the Republic of Serbia for the period 2016-2025 (draft) provides an overview of the state in this area, defines the objectives, priorities, and concrete conservation measures of FGR, but it is not entered into force. Its adoption and implementation could make a step forward in resolving the problems determined in the lack of appropriate regulatory frameworks related to the conservation and sustainable utilization of FGR in Serbia.

All relevant strategic, legal, and program documents at the national level recognize the importance of Serbia's active participation in international processes related to the conservation of biodiversity and genetic resources. International cooperation in the area of FGR conservation is very fruitful but there is a need for efficient monitoring of international initiatives as well as coordination of activities at the national level.

Therefore, based on presented state, legal frameworks, and concrete activities, priorities for FGR conservation in Serbia were defined and actions for the future were recommended. The needs for capacity building, research, and management are defined in each chapter and comprehensively classified in the last.

PART 1

THE CONTRIBUTIONS OF FOREST GENETIC RESOURCES TO SUSTAINABLE DEVELOPMENT

CHAPTER 1. VALUE AND IMPORTANCE OF FOREST GENETIC RESOURCES

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

According to the Serbian Chamber of Commerce, the wood industry (wood processing, paper, and pulp production, furniture production) has a total share of 1.4 percent (0.4 percent, 0.5 percent, 0.5 percent respectively) in GDP (Gross Domestic Product) of Serbia in 2018. Forestry has a share of 0.3 percent in GDP of Serbia in 2018. Forestry participates in the total export of Serbia with 0.1 percent, wood products with 1.7 percent, paper and pulp with 2.3 percent, and furniture with 1.9 percent (in total 6 percent). In import, forestry participates with 0 percent, wood products with 1.3 percent, paper and pulp with 2.9 percent, and furniture with 0.7 percent (in total, which is 4.9 percent).

According to the Serbian Chamber of Commerce, the total export of all wood products from Serbia in 2018 was $ 587 million (furniture - 247 million, other wood products - 340 million), which is more than $ 85 million more than in the previous year. The wood industry (technical wood, timber, and furniture) has a share of almost 6 percent in Serbia's exports. The trade balance is significantly positive.

According to the OECD (Organisation for Economic Co-operation and Development) definition of rural areas, in Serbia the rural area accounts for 75.1 percent of the country's territory, encompassing about half of the total population (49.9 percent). The average population density in Serbia is about 93 inhabitants per km^2. In rural areas, it measures 62 inhabitants per km^2 and in urban areas 289 inhabitants per km^2.

Forestry is, besides agriculture, the most important primary economic activity in rural Serbia. Yet its potentials are far from being sustainably utilized. Rural Serbia is very fragile. Poverty is primarily concentrated in rural areas (290,607 of 2,763,060 inhabitants or 0.5 percent), especially in the region of South and East Serbia (13 percent). About half a million inhabitants are unable to satisfy minimum existential needs. A recent slight decrease in the number of poor is primarily a consequence of outmigration. Gender inequalities in the area of economic participation are very expressed among rural populations. Forests multifunctionality need to be used in full extent, so all their possible functions should be explored, enlisted, and reconsidered for contributing to the local economy with other natural resources.

Quantity and value of main marketed goods, including non-wood forest products, represent significant income for people in rural areas. The value of main marketed forest ecosystem services, like biodiversity conservation, recreational functions, protective functions, and historical values, cannot be evaluated separately because of particular calculation forms, but it is displayed like other revenues in forestry enterprises financial balance sheets.

The traditional rural economy of Serbia includes various modes of forest ecosystems use. The contemporary rural economy, however, is less diversified. For 90 percent of the rural population, the forest is nowadays only the source of firewood. The secondary forest products as the source of income are quite underestimated. Presently, only about 5 percent of rural inhabitants in Serbia collect mushrooms, medicinal herbs, and fruits in forests, mainly to sell them to wholesale buyers. Products collected in nature and destined for remote markets are usually poorly paid by local buyers. This makes profit go beyond the

local communities while creating enormous pressure on exploited resources. About 1 percent of the population uses raw materials from the forest to add value locally. Valorization of these products occurs outside the local area, while realization through tourism or local processing is scarced practice. Agroforestry production systems also contribute to rural economies, especially in marginal mountainous rural areas, but silvopastoral systems that dominate the agroforestry of Serbia is radically decreasing for decades in marginal areas, where used to represent an important part of local economies and efficient tool for diversifying the use of forest ecosystems.

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

Forest genetic resources (FGR) are the single most important repositories of terrestrial biological diversity. Within the available gene pool, special attention should be addressed to the wild woody fruit species and relic, endemic, rare and endangered species (Annex 1.1).

FGR provide a *wide range of products and services* to people in Serbia. The most important forest products recognized by local communities in Serbia are timber (firewood), widespread forest fruits and other edible plants, mushrooms, medicinal and aromatic plants ("wild fruits") and game (for meat), as well as the use of materials for making natural dyes, processing leather and non-biological resources such as stone, clay, gravel, sand, etc. For all these products to be available, forest ecosystem stability is required which depends on the level of genetic variability.

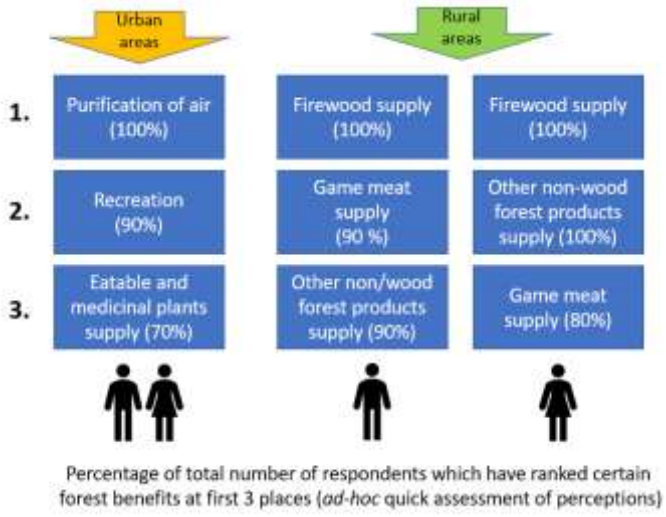
Forest trees and other woody plants help support many other organisms and have developed complex mechanisms to maintain high levels of genetic diversity. This genetic variation, both inter and intraspecific, serves a number of fundamentally important purposes. It allows trees and shrubs to react to changes in the environment, including those triggered by pests, diseases, and climate change. It provides the building blocks for future evolution, selection, and human use in breeding for a wide range of sites and uses. And, at different levels, it supports the aesthetic, ethical, and spiritual values of humans.

Forest management for productive and protective purposes can and should be rendered compatible with conservation through sound planning and coordination of activities at national, local, and regional levels. Conservation of forest biological diversity, which includes forest genetic resources, is essential for sustaining the productive value of forests, and for maintaining the health and vitality of forest ecosystems and thereby maintaining their protective, environmental and cultural roles. Forest genetic resources constitute an intergenerational resource of vast social, economic, and environmental importance.

The *poor availability of data* in Serbia makes it very difficult to define and describe all forests' socio-economic functions and benefits for local rural communities in specific. Assessing forest contributions to local communities is, besides exploring and mapping natural resources, about recognizing rural culture through history and identifying diverse territory related knowledge sources. On the other hand, *ownership and management rights* on forests seem to be very critical for the benefits local communities can obtain from forests. More thorough research will be needed especially in areas where forests non-wood products utilization used to be prosperous.

The increasing demand for wood, as a raw material for various purposes, as well as general useful forest functions, has made the protection (conservation) and directed utilization of forest genetic resources became a priority task of forestry science and profession. Today we are recording a large number of *various destructive activities*, which significantly reduce areas under forests. This is especially dangerous in cases where the destruction is done in populations of forest trees with limited or disjunctive areal, in rare ecotypes within a limited habitat, as well as in cases of endemic-relict forest tree species.

In most countries, as well as in Serbia, *valorization of forest ecosystems is related to the production of timber and firewood*, which represents less than one-third of the total economic value of a forest ecosystem, to include non-market values such as carbon sequestration, protection of watercourses, recreation and conservation of biodiversity, especially on the genetic level. The reliance of poor rural population on the functions of forest ecosystems is rarely measured and is usually not included in valorization, consequently, it is often omitted in national statistics and poverty assessments, which further leads to the development of *inappropriate strategies* that *do not appreciate the role of environmental protection in combating the poverty*. For example, forest genetic diversity is one of the driving forces of rural tourism development which is a significant potential for local community wellbeing.



Percentage of total number of respondents which have ranked certain forest benefits at first 3 places (*ad-hoc* quick assessment of perceptions)

The local importance of species may vary over time in response to different environmental conditions. When discussing forest benefits in Serbia, different lists could be compiled depending on the individual's and groups' perceptions. First of all, *urban and rural population* will create completely *different lists of top benefits* due to differences in the environmental availability of different sources. Rural people will put on the top firewood, while urban will highlight wide socio-economic benefits such as regulatory functions, recreational function, etc. In marginal areas, in traditional rural environments with elderly population forests are providers of energy and food, materials for housing, maintaining health. For the population from the local urban centers, forests are places for employing the workforce. For inhabitants of remote abandoned rural areas, forests are a source of survival that is capable to mitigate risks of extreme poverty.

While poor villagers of suburban areas of Belgrade will collect deadwood from public forests around to survive winter, others will cut their own or public forests (legally or illegally), collect „wild fruits“ or hunt wild game to conserve them for own use and provide wood security in South-East Serbia, while others will go beyond own bare necessities and exploit some to sell it to a more remote user (in areas with strong processors such as Sumadija, Western Serbia, etc.), to obtain money for other needs.

And, while some of the traditional forest benefits, exploited for ages as a prevailing practice without too many innovations, one can also find some very special, such as a collection of fossilized wood from old forests (Morava River), which are exported as a relatively cheap raw material for processing to exclusive and expensive furniture. According to Djordjević-Milošević (2019), the urban population has enlisted ecological function of purification of air as the top one, then the social function of recreation as the second one and source of wood and "wild fruits" (edible, medicinal and aromatic plants and mushrooms) as the third one. Respondents from the rural areas placed firewood as the top one, game meat as the second one, and other non-wood forest products as the third one. In urban areas there was no gender-related difference, while in rural order of last two were reordered depending on gender – women were placing "wild fruits" in second place and men game meat. What is certain is that *differences in perception of forest values* derive from the level of dependence of the urban and rural population on forest services and different lifestyles. *Taking regulation functions as granted* is common in Serbia, since enabling *regulation of natural processes*, such as reduction of the greenhouse effect, purification of water, air, and soil is considered as *impossible to vanish*.

Urban population mentioned supply function as important, yet ranking it lower than rural, which implies that their ability to provide food and medicines seemingly from other sources than the forest is preventing them understand supply (economic) forest service. For poor, using forest supplies is a necessity and for them, it is a top priority not just considering forest services, but sometimes in general. These might also include medicines and aromatic substances, and regularly energy of wood, which appears priority for the rural population in general (including also small urban centers with no other energy supply alternatives).

This variety of experiences and perceptions of forests benefits in Serbia requires *species-specific approach to forest management*. During recent years, species-specific *technical guidelines*, targeted at practical forest managers, have also been developed based on available knowledge of the species and widely accepted methods for the conservation of forest genetic resources. The on-going efforts focus on how to support the practical implementation of gene conservation; for this purpose, so-called "common action plans" are being developed for several pilot tree species. The common action plans aim at sharing responsibilities in the conservation of forest genetic resources among the countries and identifying gaps in these efforts at the pan-European level. This involves improving information management and obtaining geo-referenced data on the existing gene conservation units of forest trees throughout their entire distribution ranges in Europe for further analyses and strategy development. This species-specific approach to forest management through the implementation of conservation methods can be considered as a *high priority in Serbia*.

Considering the above-mentioned priority objectives for assessing and improving the contribution of forest genetic resources to sustainable forest management, climate change adaptation, and mitigation, food security, nutrition and poverty alleviation in Serbia can be defined as follows:

- ✓ Weakness: Poor availability of data to define and describe all FGR socio-economic functions and benefits for local rural communities

Priority objectives: Develop an interactive cadastre on the importance of FGR with the presentation of all *in situ* and *ex situ* conservation capacities along with forest products and services provided by sustainable forests on the country level: detailed field assessments should consider typical examples of forest products, elaborated with focus groups in territories which are the most famous for the concrete product and in areas where new or innovative products are emerging. The assessment might include not just the primary product, but also products that derive from the secondary and tertiary sector (processed forest product or forests ecosystems related services, such as various ecotourism products, etc.).

- ✓ Weakness: Ownership and management rights on forests are not clearly defined and presented to local communities
  Priority objectives: Support networking of private forest owners to improve the efficiency of the small-scale forestry management; assess the representation of FGR conservation topics in strategic frameworks for environmental protection and define guidelines for improvement; integrate FGR into local development strategies and elaborate all FGR socio-economic functions and benefits for local communities.

- ✓ Weakness: Various destructive activities, which significantly reduce areas under forests and cause genetic erosion in forest ecosystems.
  Priority objectives: Conduct an assessment of the vulnerability of rare and endangered species of forest trees involved in programs of *in situ* conservation to endangering factors; conduct an impact assessment of different management systems on FGR conservation in accordance with climate change; assess the existing system of forest species provenance regions in relation to needs for genetic variability high level; determine the status of forests in private ownership from the aspects of genetic resources conservation; develop a long term program for assessment and monitoring of endangering factors influence on FGR and the adaptability of forest tree species to environmental changes; expand and diversify financing mechanisms and sources of finance for conservation activities with the aim of forest ecosystem stability improvement and providing of wider range of forest products and services (rural development support measures, forestry non-specific support to social inclusion, SMEs, innovations, public-private partnerships and similar).

- ✓ Weakness: Incomplete valorization of forest ecosystem emphasizing its economic functions and neglecting its non-market values; different perceptions of the urban and rural population regarding FGR benefits.
  Priority objectives: Conduct an in-depth survey on community perceptions regarding FGR benefits in urban and rural areas; diversification of the rural economy through the introduction of tourism-related activities relied on sustainable forest ecosystems; diversification of the rural economy through an introduction or strengthening forest food supply chains (investments in processing equipment for Non-Wood Forest Products (NWFP) or gastronomy); support to sustainable High Nature Value Farming (HNVF) practices and agroforestry systems for sharing benefits between agro-diversity conservation and maintaining forest genetic resources; develop a long term national program for the comprehensive valorization of FGR in urban and rural areas including all forest functions and benefits.

- ✓ Weakness: Inappropriate strategies that do not appreciate the role of environmental protection and FGR conservation in combating poverty.
  Priority objectives: Advance general cross-sectoral cooperation among forestry, water, soil and rural development sectors including the development of cross-sectoral forest information systems with accurate data and on-line information exchange system; plan FGR conservation based on collaborative management which brings the community into the decision-making process, involving local people in the discussion, negotiation, and planning, having in mind that people live with forests and vice-versa.

- ✓ Weakness: Local communities in Serbia take regulation functions as granted and regulation of natural processes by forests is considered impossible to vanish.
  Priority objectives: Raising awareness of forest owners and users about the importance of conserving forest genetic diversity which can significantly contribute to the improvement of FGR contribution to food security and poverty alleviation; develop guidelines about the vulnerability of forest ecosystems and importance of its conservation and sustainable use; develop guidelines for the introduction of international recommendations for evaluating ecosystem services in national and local strategic and legal frameworks; create the concept of support for FGR conservation through supporting local communities to benefit of forests multifunctional role.

- ✓ Weakness: Lack of species-specific approach to forest management and FGR conservation.
  Priority objectives: Develop separate programs of genetic conservation for forest tree species in natural protected areas and at specific stands; develop a conservation and breeding program for forest tree species of economic importance; define a national list of important species from various reasons and develop species-specific technical guidelines, targeted at practical forest managers, based on available indigenous knowledge of the species and widely accepted methods for the conservation of forest genetic resources; develop "common action plans" for pilot species which aim at sharing responsibilities in FGR conservation among the regions and stakeholders.

The contributions of FGR towards relevant Sustainable Development Goals

	End poverty in all its forms everywhere	- Provide incomes to poor and marginal communities - Low cash inputs suitable to poor and marginal communities - Lower rates of rural-urban migrations for work - Sustainable income from sustainable forest ecosystems - A driving force of rural tourism development
	End hunger, achieve food security and improved nutrition and promote sustainable agriculture	- More food available from forests - More nutritious food from forests - High genetic variability of seeds and planting material - Maintaining of gene and seed banks - Climate-Smart Agriculture promotion - Sustainable Agriculture through diversified activities
	Ensure healthy lives and promote wellbeing for all at all ages	- Healthier diets for sensitive groups (children and elderlies) - Forest fruits nonexposed to chemicals improve health - Forest health-recreational functions improved - Forest aesthetic and spiritual functions improved

	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	- Equal opportunities for education in marginal communities - Spending more on children's education in rural areas - Lifelong learning about conservation issues - Networking formal and non-formal education for wellbeing
	Achieve gender equality and empower all women and girls	- More employment opportunities for women and elderlies - More income through the creation of FGR added value - Avoiding rural-urban migration of women and young people
	Ensure availability and sustainable management of water and sanitation for all	- Protection of watercourses - Purification of water - Purification of underground waters (rural wells) - Prevention of drought periods - Prevention of floods and floodwater diseases
	Ensure access to affordable, reliable, sustainable and modern energy for all	- More firewood from sustainable forests - Higher energy density of firewood - Production of biomass from forest residues - Selection for energy plantations establishment
	Promote inclusive and sustainable economic growth, employment and decent work for all	- Stimulate local economy while not harming the environment - Job opportunities for the whole working-age population - Work in a healthy environment
	Build resilient infrastructure, promote sustainable industrialization and foster innovation	- Increased resource and energy efficiency - Higher level of construction wood quality - Soil erosion prevention - Molecular-genetic analysis innovations - *Ex situ* conservation innovations
	Reduce inequality within and among countries	- Poverty reduction in marginal areas - Bridging urban-rural life inequality gaps - Air purification for all
	Make cities inclusive, safe, resilient and sustainable	- Improved urban green infrastructure - Air purification in urban zones - Conservation of urban forests - Additional income for people from local urban centers
	Ensure sustainable consumption and production patterns	- Promoting resource and energy efficiency - Green jobs opportunities - Lifelong learning about sustainable management - Ethical consumerism from environmentally-friendly chains
	Take urgent action to combat climate change and its impacts	- Selection for sustainable afforestation - Carbon sequestration by sustainable forest ecosystems - Sources of renewable energy - Mitigation of extreme weather conditions impacts
	Conserve and sustainably use the oceans, seas and marine resources	- Reduction of river water pollution - Conservation of riparian ecosystems - Conservation of wetlands

	Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss	- FGR management is an essential approach for this goal
	Promote just, peaceful and inclusive societies	- Promote forest as a public good - Provide equal chances for a quality environment for all - Forest recreational function as stress prevention
	Revitalize global partnership for sustainable development	- Ratification and implementation of international agreements - Participation in FGR international networks - Multi-stakeholder approach/collaborative FGR management - Public-private partnerships - Implementation of policies for poverty reduction

PART 2

STATE OF DIVERSITY IN FORESTS AND WOODLANDS

CHAPTER 2. STATE OF FORESTS

State of forests and trends in their management

Serbia is considered to be a middle-forested country with a forest cover rate of 29,1% (a total of 2.252.400 ha) (FRA, 2015) and with positive annual change rate in the period from 1990 to 2015 of 0,7% (Table 2.1.).

Table 2.1. Forest and forest land in 2015 the Republic of Serbia

Vegetation form	Total (ha)
1. High forest	796,000
2. Coppice forest	1,456,400
1+2. All forests	2,252,400
3. Shrubbery	n/a
4. Barren	92,000
3+4. Shrubbery and barren	92,000
5. Other forest areas	382,400
6. All forest and forest land	2,634,800

Source: GIZ (2017)

According to the Statistical Office of the Republic of Serbia data from 2019 (without data from Kosovo and Metohija Province), the forest area in 2017 in the Republic of Serbia was in total 2,237,511 ha: state ownership 963,458 ha, private ownership 1,274,053 ha. The area of forested land in state and private forests, without raising plantations and newly planted areas, was 1984 ha in 2017 ha and 1547 ha in 2018. Raising plantations and protective belts in state and private forests were on 879 ha in 2017 and on 695 ha in 2018.

Over 92% of forests are semi-natural, followed by the planted forests and plantations (7,8%), while the virgin forests occupy only 0,1%. Concerning the species composition, the most of the forests are covered by European beech (29,4%), followed by Turkey oak forests (15,3%), forest group of acacia, aspen, and birch (9,9%), Sessile oak forests (7,7%), Hungarian oak forests (7,1%), pine forests (5,6%), hornbeam forests (5,3%), and spruce forests (3,8%).

Even with a positive annual change rate, the national forest cover percentage is undesirable compared to an optimal level of 41.4 percent defined in the National Spatial Plan. Besides that fact, the distribution of forest cover over the Republic's territory is uneven and there is a large proportion of forests are of coppice origin (64,7%), with low annual increment and unfavorable age structure.

Present conditions of forests require more attention, to silvicultural and better utilization of stand and sites potentials regarding wood production. Nevertheless, concerning forest resources in general, the following can be concluded (GIZ, 2017):

- The insufficient average value of volume and volume increment per ha.
- Unfavorable structure by origin. Nearly two-thirds of forests are coppice, with an average volume of 124.4 m^3/ha and a volume increment of 3.1 m^3/ha (compared to high nature forests (253.6 m^3/ ha and 5.5 m^3/ha).
- Unfavorable structure by structural form (even-aged forests dominate with 91.6 percent).

- There is 608,000 ha of insufficiently stocked forests (27 percent of the total forest area) with the average annual wood production being 3.1 m^3/ha.
- Irregular age class distribution. The percentage relation of young: middle-aged: mature: over matured forests is 38:20:13:29 for high nature forests and 51:33:7:9 for coppice forests.
- Unfavorable assortment structure of growing stock regarding wood volume: round wood (33.5 percent) and fuelwood (66.5 percent).
- Unfavorable access to forests by forest roads. At the level of Public Enterprise „Srbijašume"- 11.86 m'/ha, for PE „Vojvodinašume"- 9.09 m'/ha, for National parks from 14.88 to 18.3 m'/ha. Another issue is the low quality of forest roads, mainly passable in dry (summer) seasons, which complicate the transport of timber. Also, the safety standards and labor law in this part of the forestry sector are far below western standards.
- The usage of non-wood forest products and biomass production is underdeveloped.

Forest management approaches in Serbia largely depend on the category of ownership. Regarding the ownership structure in Serbia, there are two types of ownership: state (53 percent) and private (47 percent). By the law, public and private forests are considered to be equal ownership categories. Private forests got their recognition as an ownership category, contrary to the past times when they had been mostly neglected. Public/state ownership includes land owned by the State or government-owned institutions or co-operatives or other public bodies including cities and educational institutions. Private ownership includes land owned by individuals and religious communities.

In private ownership appears, for the first time in 2015, the ownership by private business entities and institutions on an area of 23,000 ha. It should be noted that in the statistics related to private forests, the category of monastery and church forests, which have been returned through the process of restitution, has not been distinguished as a separate category and they belong to the category of private forests. There is another unclear situation regarding the ownership of the forests that belong to the legal entities that have arisen with the privatization of former cooperatives, public companies, and factory farms. However, there are no official data about this (Forest Land Ownership Change in Europe - Country Reports, 2015).

The Ministry of Agriculture, Forestry and Water Management implements forest management and protection related activities through a Forest Fund, providing services and supporting the implementation of sustainable forest management in public and private forests. Other important institutions are the Ministry of Environmental Protection, the Public Enterprises for Forest Management and the National Parks which administer all public forests, the Forestry Institutes and the Faculty of Forestry as the main research and development institutions. International cooperation in the forestry sector is intense with the European Union and the Government of Germany.

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

Although the total forest cover rate in Serbia is constantly increasing (Ivetić, 2015), in most of the districts the decrease in forest cover is recorded. The main causes of the forest cover loss are illegal logging, as well as unplanned logging associated with intensified

dying of forests, due to the occurrence of extreme events, primarily extreme drought, as well as windthrows, ice storms, fire and attacks by pests and diseases. Considering that climate scenarios are the basis for predicting longer periods of drought and more frequent extreme events, it is to be expected that the processes related to the dieback of forests will intensify in the future. Another negative outcome, related to some extent to the extreme events, is the lack of planned natural regeneration on a significant part of the area of high forests (268.000 ha).

Drivers affecting forest genetic resources in Serbia can be classified as follows:

Illegal logging and overexploitation along with resulting habitat loss and fragmentation
The main current environmental problem in forestry is forest destruction and degradation by illegal logging occurring across the whole country. The main reason for illegal logging in Serbia is the difficult economic situation in rural areas (households logging for firewood or small-scale sale at the local market). Illegal logging occurs in different degrees in all categories of forest ownership. However, the most vulnerable to illegal logging are forests of private owners who live remotely from their forest properties and who are not able to take care of their properties. The most frequent assortment that is subject of illegal logging is firewood, which is sold to private households, with no documentation and bills.
Regarding the volume of logged wood, the highest amounts are those logged in private forests by the forest owner, not priory approved by the competent professional services. By definition, these loggings constitute illegal logging although they cannot be qualified as a criminal activity. In the state forests, illegal loggings are present to a lesser extent and it does not constitute a threat to the sustainability of forest management. Illegal logging is very important from the points of forestry and environmental protection and practically the main activities in suppression thereof are still under the competence of the forestry sector.
In accordance with the Statistical Office of the Republic of Serbia, damage to the state forest caused by illegal logging was 111,879 m^3 for the period 2013-2017 year. Almost all illegally felled trees were removed from the forest (Table 2.2).

Table 2.2. Damage to forest caused by illegal logging

Damage to forest caused by illegal logging (m^3)				
Year				
2013	2014	2015	2016	2017
17,601	26,086	22,892	20,169	25,131

Source: SORS (2019); No data from Kosovo and Metohija Province

Illegal activities data consists of two data sources: official statistics and the internal data of the Directorate of Forests (DOF). DOF data shows a 5.5 times larger amount of cut wood on an annual level. The discrepancy is mainly in fuelwood where the significant amount has a final destination at a 'grey zone market', outside of the legal flow. Besides this figure, sustainability is not jeopardized yet, but the following trend is a concern. Illegal logging and overexploitation of wood for fuel or wood industry, are a significant threat to forest genetic resources. Clear cuts lead to the devastation of habitats for different forest species and development of secondary ecosystems characterized by decreased diversity, as well as to forest fragmentation. For tourism, there was significant deforestation in Serbia, mostly to build ski-runs and associated infrastructure in mountain centers, which has led to significant ecosystem fragmentation. Forest fragmentation leads to the diminution of genetic diversity, due to reduced gene flow.

Reduction and fragmentation of natural populations lead to disturbances inside the ecosystems, including the species ratio. Forest fragmentation leads to reproductively isolated smaller populations, and inbreeding in small populations can destroy their genetic diversity. In addition to clear felling, logging of very old trees (whose age exceeds a hundred years, sometimes hundreds of years) is a threatening factor for forest genetic resources. Harvesting of such specimens is mainly due to their great age and poor health, resulting in the loss of extremely valuable genotypes, characterized by remarkable adaptive potential, since they have survived at the site, despite numerous biotic and abiotic threatening factors. It is necessary to take measures for the conservation of such trees and to collect material for storage in the forest trees gene banks.

Changes in natural habitats are mainly caused by changes in the use of forest land (agriculture, infrastructure development, and urbanization, mining, etc.). Replacing natural habitats with artificial ones is detrimental to the survival of many native species, leading to a change in the gene pool of forest species. It is very important to strike a balance so that the exploitation of the plant species is moderate and consistent with their ability to reproduce, avoid their endangerment, or their disappear.

Forest fires

High intensity and frequency of fires may affect the sustainable management of forests to a certain extent. There is a general concern that the territory of Serbia has been affected by an increasing number of forest fires and this trend can cause substantial losses to forestry. In Serbia, in the period from 2003 to 2015, the total burned area (42.2%) was in beech forests. According to the Statistical Office of the Republic of Serbia (SORS, 2019), 6,067 m^3 of wood in state forests was affected by fires in 2017 while that amount in private forests was 5,350 m^3. In state forests, there were 70% of low fires and 30% of high fires. This relation in private forests was 4% of low fires vs 96% of high fires. Serbia has already recorded an increase in the frequency, intensity, and duration of droughts. This trend will in the near future be particularly expressed in the southeast and east of Serbia. Forest fires affect the forest ecosystem, and often seriously hinder its functioning over a longer period before it is restored to the state before the fire. Proces of revitalization forest ecosystems is a matter of making the right choices, especially from the aspect of the income effect. Since the revitalization of forest ecosystems requires significant financial funds, these sites are often left to natural regeneration. On the other hand, it is questionable whether the investment into the establishment of forest stands with the species that used to grow at these locations is reasonable at all. In this situation, the restitution of these forests after they have been damaged by forest fires is of huge economic importance. The process of forest restitution raises the issue of financing and assessing the profitability of the investment.

Invasive and exotic species

The spread of allochthonous species has been largely aided by previous ecosystem changes. Disturbances of vegetation in ecosystems, such as those caused by deforestation or forest fires, allow faster distribution of allochthonous than native species, as they are more competitive, leading to significant suppression or extinction of native species. Invasive species are also a greater threat where ecosystem disruption has previously occurred and their impact is exacerbated by climate change. These species reduce the diversity of forest species, displacing native species from natural habitats, changing the structure of populations, and threatening the stability of ecosystems.

The Convention on Biological Diversity contains an important objective in forest management: preventing the spread or, if necessary, suppressing invasive species. Not only does their spontaneous spread endanger natural vegetation, it significantly increases the cost of forest care and restoration. According to the Provincial Institute for Nature Conservation, the following tree species are invasive in the area of the Pannonian Biogeographical Region: box elder (*Acer negundo* L.), tree of heaven (*Ailanthus altissima* Mill/Swingle), false indigo-bush (*Amorpha fruticosa* L.), American hackberry (*Celtis occidentalis* L.), green ash (*Fraxinus pennsylvanica* Marsh.), thorny honeylocust (*Gleditchia triachantos* L.), black cherry (*Prunus serotina* Ehrh.), Siberian elm (*Ulmus pumila* L.), and in some habitats also black locust (*Robinia pseudoacacia* L.). Based on the preliminary list of invasive species in the Republic of Serbia, made by the Institute for the Protection of Nature of Serbia, as a highly invasive species in Serbia, are listed: box elder (*Acer negundo* L.), false indigo-bush (*Amorpha fruticosa* L.), tree of heaven (*Ailanthus altissima* Mill/Swingle) and black locust (*Robinia pseudoacacia* L.). As sporadically invasive species, the same authors enlist the following: American hackberry (*Celtis occidentalis* L.), American ash (*Fraxinus americana* L.), green ash (*Fraxinus pennsylvanica* Marsh.), bird cherry (*Prunus padus* L.), black cherry (*Prunus serotina* Ehrh.) and Siberian elm (*Ulmus pumila* L.).

Pests and diseases

One of the main goals of conservation of FGR is their adaptation to changes in various biotic and abiotic factors that threaten them. Biotic damage is mainly caused by the spread of disease and pests in forest ecosystems, resulting in a loss of genetic diversity. Genetic diversity can be particularly threatened in forest ecosystems that have previously experienced some disturbance. Damages from harmful insects (e.g., gypsy moth) can lead to widespread drying of forests and various cases of outbreaks of certain diseases of forest species have been reported (Dutch elm disease, chestnut bark cancer, dispersal of Douglas fir needles, etc.). Plantations based on the use of genetically homogeneous material (using clones) are characterized by an increased risk of such occurrences. According to the Statistical Office of the Republic of Serbia, 27,303 m^3 of wood in state forests was affected by insects in 2017 (96 percent *Scolitidae*), and 17,504 m^3 by plant diseases.

Natural disasters

Natural disasters in forest ecosystems represent a significant disruption of biological balance and a serious threat to forest genetic resources. Damage is usually caused by wind, snow, floods, torrents, landslides, as well as other unforeseen factors on large areas of forests and forest land. Regular preventive monitoring of the occurrence of disasters is necessary to be able to act promptly. Damages by ice do not occur frequently, but they can be extremely large, as was the case in Serbia at the end of 2014. During this period, eastern Serbia was hit by a wave of low temperatures, followed by the onset of freezing rain, creating extremely thick deposits of ice. The cold period lasted about a month, followed by additional snowfall and strong winds, which made it difficult for tree canopies and caused extensive damage to forests (a large number of tree breaks and hatching of entire groups of trees). To undertake measures and activities within its competence, the Forest Administration has established a Special Working Group, which has made a proposal for measures and activities for the rehabilitation of damaged forests from ice in eastern Serbia for the period 2015-2018. According to the Statistical Office of the Republic of Serbia, 44,074 m^3 of wood in state forests was affected by natural disasters in 2017 (58% wind, 42% rain, hail, snow and frost).

Pollution

Various human activities cause pollution of water, air, and soil, which significantly affects the threat to forest resources. Air pollution is most often caused by traffic and industry and can endanger plants directly or indirectly. Due to the increased concentrations of harmful substances in the air, loss of chlorophyll can occur, the process of photosynthesis and growth can be halted, leading to the gradual extinction of the plant organs and the drying of entire plants. Aerial pollution can cause drying of forests over large areas. Air pollution affects the gene pool of forest species, by reduction of pollen production, seed vitality, and above and below-ground plant growth. The harmful substances from the air, dissolved in water, reach the soil and therefore the plants, which absorb the substances from the soil. The presence of heavy metals in soil can significantly affect the vitality of certain species. According to the results of numerous studies in Serbia, woody species are best characterized as phyto-accumulators and phytoextractors, which are of the most desirable phytoremediation techniques. Phytoextraction is the use of high plants to remove pollutants, primarily heavy metals, from the soil. In this approach, plants that are capable of absorbing contaminants through the root system and translocating and/or accumulating to aboveground parts (stems and leaves) are used. Forest trees, primarily species covered by the studies up to date, such as linden, Paulownia, Austrian pine, sessile oak, wild cherry, Douglas fir, and various clones of poplar and willow, possess the stated abilities.

Bad practices in forest management and reproductive material use

Reducing forest genetic diversity may also be affected by inadequate practices. Negative examples of practice are reflected in the felling of phenotypically superior trees before their physiological maturity while leaving those trees negatively affecting offspring quality. Inadequate legal basis or lack of implementation of existing laws and lack of institutional frameworks for managing forest genetic resources are also examples of inadequate practice. The effect of inadequate practice can also be insufficient coordination of research and involvement in international projects dealing with the topic of forest genetic resources at the national level. There is a lack of promotion and public awareness of the importance of forest genetic resources conservation. Improper afforestation, through the selection of inadequate species, can lead to the neglect of many native, endemic, and relict species of trees. The proper selection of reproductive material is very important. The collection of seed material from populations characterized by high genetic diversity is essential to maintain the variability of the species or population and to adapt it to new environmental conditions. Also, it is necessary to collect the material from some native trees to maintain variability, and preference should always be given to native species. It is mandatory to collect seeds from registered seed objects of certain species.

Water regime

Water regime is one of the important factors that can endanger forest genetic resources. Through the construction of artificial reservoirs in canyons and gorges, man has significantly contributed to the change in the water regime and the complete destruction of populations and entire ecosystems due to subsidence. Also, human interventions can lead to changes in groundwater levels. Permanent lowering of groundwater levels can significantly affect the physiological processes of a plant, while a permanent increase in groundwater levels can cause root rot (due to water retention in the root zone and reduced soil aeration) and plant death.

Climate change

The Second Report of the Republic of Serbia under the UN Framework Convention on Climate Change recognizes the following impacts of climate change on forest resources: negative impact due to drought intensification; increasing the number of fires and increasing the area affected by the fire; increasing areas affected by diseases and pests; increased mortality of forests; change of distribution and structure of forests; enlargement of areas at risk of wind; enlargement of areas at risk from ice.

Challenges and opportunities for forest genetic resources

The above-mentioned drivers and factors can be considered as weaknesses or challenges for the definition of appropriate priorities and opportunities for improvement of forest genetic resources conservation in Serbia.

- ✓ Weakness: Illegal logging and overexploitation along with resulting habitat loss and fragmentation.
  Priority objectives: Reform policies that encourage the unsustainable use of resources, the degradation or conversion of forest ecosystems for other purposes, and improve strategic and legislative frameworks in the field of forest genetic resource conservation; Establish a national monitoring program that identifies and monitors priority species, habitats and genetic components of biodiversity, as well as the causes and consequences of activities and processes that threaten them.

- ✓ Weakness: Forest fires.
  Priority objectives: Develop a national system of preventive action in forest fire protection through forest fire hazard forecasting; Introduce additional active duty in forest administrations and forest holdings during periods of increased risk of fire; Remove dry branches and keep forest pathways passable for firefighters to quickly reach the site of the fire and respond.

- ✓ Weakness: Invasive and exotic species.
  Priority objectives: Conduct an assessment of allochthonous and invasive species, to provide information on their biological and ecological characteristics and damage to native genetic diversity; Establish an alert system for allochthonous and invasive species and procedures for responding to threats from these species, develop biological and other methods, to prevent negative impacts, control and eradicate species.

- ✓ Weakness: Natural disasters, pests, diseases, and pollution.
  Priority objectives: Comparatively analyze the degree of: genetic variability and the vulnerability of forest tree populations to disease and damage; forest tree species populations genetic variability and vulnerability to pollution (water, air, soil); Proper selection of planting material during afforestation so that ecosystems are resilient to natural disasters; Perform regular health checks for the spread of pests and diseases in forest ecosystems; Develop breeding programs to improve species' resilience to natural disasters, pests, diseases, and pollution; Provide support to nurseries for the production of planting material from newly developed breeding programs to improve the resilience of forest species; Develop bio-indicators to monitor the impact of pollution on the diversity of forest species with emphasis on sensitive species or species endangered by the pollution;

- ✓ Weakness: Bad practices in forest management and reproductive material use.
  Priority objectives: Develop a system for monitoring of the state of FGR within the network of conservation areas; Introduce modern software packages for modeling ecosystem processes in relation to environmental changes in the system of forest management planning; Develop guidelines for harmonization of the management system with the highest degree of utilization of natural processes and mechanisms of self-regulation of forest ecosystems to conserve genetic variability; Develop guidelines for the inclusion of vulnerability assessment and adaptability of forest tree species into the regular forest management planning process.

- ✓ Weakness: Climate change.
  Priority objectives: Develop a long-term program to study the impact of climate change on forest genetic resources; Develop guidelines for the inclusion of priority species in intensive programs to study the impact of climate change on forest genetic resources; Make an assessment of the vulnerability of rare and endangered forest tree species to climate change; To conduct an impact assessment of different management systems on the conservation of forest genetic resources in accordance with climate change; Explore the possibilities of applying climate scenarios and models for the needs of assessing the vulnerability of forest genetic resources; Develop a long-term program of research on the adaptability of forest species to environmental changes; Explore the potentials of forest species and forest types for carbon storage; Explore the neutral and adaptive variability of relict forest species in order to define adaptation mechanisms in a wide range of different environmental conditions; Comparatively analyze the degree of genetic variability and the vulnerability of forest species populations to disease and damage; Comparatively analyze the degree of genetic variability of forest species populations and the quality of other habitat characteristics (soil, water, air and biodiversity); Assess the existing system of forest species provenance regions in relation to the needs of adaptation and mitigation of the consequences of climate change; To harmonize the legal framework related to forest reproductive material management with the expected needs of assisted migration of genetic material in accordance with the intensity of climate change; Develop programs of genetic conservation of forest species in protected natural areas and on specific habitats; Develop a monitoring system for the impact of climate change on forest genetic resources within conservation area networks; Develop a long-term program of *ex situ* conservation of forest genetic resources in accordance with climate change; Develop a long-term program of an integral approach to conservation of forest genetic resources based on an adequate combination of *in situ* and *ex situ* methods and intersectoral cooperation; Develop guidelines for introduction of Multiple Population Breeding System (MPBS) conservation method as an efficient approach to climate change mitigation; Develop guidelines for inclusion of vulnerability and adaptability assessment of priority forest tree species into the regular process of forest management planning; Develop guidelines for assessing and conserving genetic variability in private forests and to bring closer the importance of forest genetic resources to forest owners and users; Develop guidelines for ecological and economic evaluation of forest genetic resources and their conservation in accordance with climate change; Develop a long-term program for financing the conservation of forest genetic resources and identify possible sources of financing.

CHAPTER 3. STATE OF OTHER WOODED LANDS

State of other wooded lands and trends in their management

The term „*Other Wooded Lands (OWLs)*" defined by the FAO (*Food and Agriculture Organisation*) is also used at the national level: „*Land not classified as "Forest" spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of 5-10 percent or trees able to reach these thresholds; or with a combined cover of shrubs, bushes and trees above 10 percent. It does not include land that is predominantly under agricultural or urban land use.*"

According to the Country Report for Serbia for the Global Forest Resources Assessment (FRA, 2015), there was an increase in surface area of OWL between 1990 and 2015 (Table 3.1).

There is an explanation in the report that the area increased for 2005, because of FRA 2005 definitions (shrubs, bushes, and maquis excluded from forest areas).

Table 3.1. Other wooded lands area in Serbia (1990-2015)

Category	Area (000 hectares)			
Other wooded lands	1990	2005	2010	2015
	287	521	410	508

Source: FRA (2015)

The reported trend for the period 2010-2015 needs to reflect the actual situation because of compiling datasets from national inventory and the current situation of different forest users (public enterprises, national parks, etc).

Total growing stock for OWLs in 2015 (according to the FRA, 2015) was 37 million m^3 over bark, of which coniferous 5 million m^3 and broadleaved 32 million m^3. Biomass stored in OWL in 2015 was 24.8 million metric tons oven-dry weight in total of which: above-ground biomass - 20.3 million metric tons oven-dry weight; below-ground biomass – 2.5 million metric tons oven-dry weight; deadwood – 2 million metric tons oven-dry weight. Species represented in shrubs and bushes of OWLs are listed in Annex 3.1.

In 2015, carbon stored in living biomass of OWLs was 10.7 million metric tons while dead wood and litter from this area contained 9.1 million metric tons. Much more carbon is store in OWLs soil and it was assessed to be 48.3 million metric tons. Total carbon stored in OWLs was 68 million metric tons (compared to total carbon stored in forests for the same year which was 572.2 million metric tons).

According to the National Forest Inventory (NFI, 2008), there is no more recent data because new forest inventory is in progress), other wooded lands, including bushes and shrubs, cover a total of 382.400 ha, or 4,9% of the territory of Serbia. The national definition of OWLs does not include areas with trees and shrubs less than 0.5 hectares or narrower than 20 meters as well as windbreak belts because it's predominantly used in agriculture.

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

The area declared as OWLs has been changing over the past three decades in Serbia, primarily because of the new FAO definition of this category. Thus, this area was the largest in 2005, when the definition according to which shrubs, bushes, and maquis belong to this category (that is, they were separated from the category of forest and forest land) was applied.

In addition to applying a different definition, other drivers affect the change in surface area and condition of OWLs in Serbia. These drivers can be categorized into two groups: a) *drivers that cause increase of OWLs area* and b) *drivers that cause decrease of OWLs area*.

a) Drivers that cause an increase of OWLs area:

- *Illegal logging and overexploitation*: illegal logging and over-exploitation lead to a decrease in forest area, as well as damage to canopy and structure of forest ecosystems, to the extent that some parts of them receive OWLs status (i.e., areas covered by trees, shrubs and bushes are described as OWL) if adequate restoration is not carried out (as stated in Chapter 2, Serbia lacks planned natural restoration of forest habitats on as many as 268,000 hectares).

- *Habitat loss and fragmentation*: habitat loss and fragmentation, as a result of unprofessional interventions, first of all in private forests, as well as illegal logging and over-exploitation, new surfaces can be identified that can be declared as OWLs unless adequate restoration is carried out.

- *Forest fires*: forest fires, the most commonly caused by human activity, can cause extensive damage to forest ecosystems, leading to their fragmentation and the creation of open areas under individual trees, shrubs, and bushes due to the natural succession of vegetation in the fires.

- *Natural disasters* (wind, frost, ice, and drought): natural disasters can cause extensive damage to forest ecosystems, creating the potential for new areas to emerge under OWLs due to inadequate restoration of such ecosystems.

- *High Nature Value Farming (HNVF)*: HNV Farming systems are typically characterized by a combination of: low-intensity land use; the presence of semi-natural vegetation; and diversity of land cover and land use. They maintain important habitats both on the cultivated or grazed area and in features such as hedgerows, ponds, and trees, which historically were integrated with the farming systems. According to Typology of HNV Farming Systems for Serbia, afforested HNVF exist within a subgroup of *Livestock systems* (type: *Forests and wetlands pastures based grazing systems*). These systems are silvopastoral, based on grazing in lowland oak forests (for example Srem Region), grasslands in highland beech forests, and mixed beech/spruce forests (such as mountainous areas of Carpathian-Balkan Mountain Chain and Dinaric Arch) and lowland riparian ecosystems (Bačka and Banat Regions, etc.).

- These farmlands are by the nature of vegetation and its origin enlisted as forest lands. Continuous use of these habitats for grazing causes the stability of existing forest vegetation to be disturbed, and over time the stands become shrubby on small areas.

- *Deciduous forests pruned for winter forage* is an extensive mountain sheep system, with winter forage collected from deciduous forests. It involves the pruning of deciduous trees and the collection of branches and leaves which were then dried and stored for animal feed. Such treatment of the trees leads to the disturbance of their crowns and the transition to a shrub, which over time can cause a complete disruption of the stability of the forest ecosystem and cause the appearance of shrubs.

- *Climate change and pollution*: climate change results in the drying of forests due to changes in climate parameters, combined with pollution of air, groundwater and surface water, and soil. With the long-term effects of these factors, the vitality of forest ecosystems is diminished, resulting in the drying and dying of trees on larger areas. If there is no adequate restoration in these areas, natural succession of vegetation occurs and the occurrence of shrub species on areas larger than 0.5 hectares.

b) Drivers that cause a reduction in surface area of OWLs:

- *Adequate natural regeneration of forest sites:* planned natural regeneration of forest sites (which is missing in as many as 268,000 ha) is one of the main drivers for reducing the area of OWLs. Forest sites that have been adequately restored after fires, natural disasters, illegal logging, drying of forests, and other adverse factors retain the potential to remain in the forest and forest land category without the risk of natural succession of vegetation and species of shrubs and bushes occurring in such situations.

- *The first afforestation of OWLs:* which has never been under forest before, is a significant driver for reducing their area. These lands represent optimal areas for the establishment of new forests because this does not take up land suitable for agricultural production to increase the area under forests.

- *Controlled application of HNVFs and site restoration*: in local communities where awareness that farm systems must be consistent with the sustainability of forest ecosystems exists, adequate farmers' behavior is one of the main drivers for reducing OWLs. In such cases, forest ecosystems remain vital, non-disturbed in structure and canopy, which reduce the possibility for conversion in shrubby vegetation and shrubs. Also, where restoration of sites with disturbed forest ecosystems is carried out, there is a possibility of preventing the spread of the area under OWLs. Unfortunately, the awareness of the local community on this issue is quite low, and activities to restore such sites are rare.

Challenges and opportunities for forest genetic resources

The above-mentioned drivers and factors can be considered as weaknesses or challenges for the definition of appropriate priorities and opportunities for improvement of OWLs genetic resources conservation in Serbia.

All drivers listed as factors leading to an increase in OWLs area can be considered as an opportunity to enhance the diversity of shrub species suppressed within forest ecosystems. All species listed in Annex 3.1 have the opportunity to increase the level of within-species diversity with an increase in their distribution. On the other hand, this trend is unfavorable, as it leads to a decrease in areas under vital forest ecosystems and negatively affects forest genetic resources. Individual trees of woody species present on OWLs have a reduced ability to cross, and the degree of inbreeding is high, compromising the resistance and adaptability of offspring. Trees that are mechanically damaged, very often, also have a reduced ability to reproduce.

All drivers that result in the reduction of OWLs area are very favorable for increasing the genetic variability of woody species, as they increase the area under vital forest ecosystems. Adequate site restoration, proper selection of species and use of selected planting material (especially if a national system of certification of seed and planting material is developed) is a great opportunity to improve forest genetic resources. Also, increasing the area under forests by first afforestation of OWLs offers the same opportunity to forest genetic resources. On the other hand, shrub species are suppressed by the dominance of forest trees.

The choice of an appropriate approach in a particular area depends on the purpose and environmental characteristics of the area itself. The rational ratio between forest and other forest land depends on the characteristics and degree of threat to the site, as well as the needs of the local community in the area. Other forest lands significantly contribute to the conservation of biodiversity in general, i.e. they provide significant support to populations of insects, birds, micro-organisms, and are important for maintaining the cultural landscape of rural areas, which is valorized through ecotourism. For this reason, OWLs should not be viewed as a negative item per se, aiming exclusively to reduce their area, but should be maintained and preserved in areas where there are reasonable grounds for doing so.

CHAPTER 4. STATE OF DIVERSITY BETWEEN TREES AND OTHER WOODY PLANT SPECIES

Serbia is a continental country located in the eastern part of southern Europe, in the central part of the Balkan Peninsula. The Balkan Peninsula is one of the three Mediterranean peninsulas and is known as one of Europe's biodiversity centers. Since the northern parts of Serbia also belong to the Pannonian Plain, Serbia also partly belongs to the Central European region.

Although the surface of the Republic of Serbia is only 88,361 km^2, which makes up only 2.1% of the mainland of Europe, the biodiversity of different groups of living organisms is high. Specific diversity in the Republic of Serbia is not well documented since not all groups of organisms have been adequately researched. Nevertheless, an approximate number of taxa of some better-studied groups of organisms is known. According to the 2011 data, the number of species in the vascular flora group (*Pterydophyta*, *Pinophyta*, *Magnoliophyta*) is 3,662 (OG, 2011).

According to IUCN (International Union for Conservation of Nature) data, the Republic of Serbia is one of six biodiversity centers in Europe and one of 153 world biodiversity centers. There are 61 Important Plant Areas (IPA) in its territory. According to data from the 4th National Report, which is attached as documentation for the implementation of the UN Convention on Biological Diversity, published in 2010, 39% of the vascular flora of Europe and 40% of the moss and fern flora are in Serbia. In Serbia, 287 species of plants are endemic to the Balkans, accounting for 8.06% of Serbia's flora (INC, 2020).

The main type of endemism in Serbia is high-altitude endemism, which is the case in the entire territory of the Balkan Peninsula. Local endemics make up about 1.5% of Serbia's total flora (59 species), while Balkan endemics make up about 14.94% (547 species) (Popović et al., 2017).

Number of tree and other woody plant species that are considered as "forest genetic resources" and managed or utilized in the forestry context

According to the Forestry Development Strategy of the Republic of Serbia (OG, 2006), Serbia's primary interest is the conservation and enhancement of the very rich biological diversity, mainly contained in forest ecosystems. The forest ecosystems are composed of about 250 native woody species belonging to the Central European, Pontic, and Mediterranean elements according to the geographical-floral elements, and the presence of 88 wild woody fruit species is of particular importance for forest genetic resources (INC, 2020).

According to data from the National Forest Inventory of Serbia (NFI, 2008), forest genetic resources consist of 49 tree species, of which 40 are hardwood and 9 conifer species, which are differently represented in the Serbian Forest Fund (Annex 4.1, Figure 4.1).

The number of trees in the forest fund of the Republic of Serbia is represented by hardwoods with 91.1% and conifers with 8.9%. The most common are the following hardwood species: beech (*Fagus sp.*) with a share of 20.6%, common hornbeam (*Carpinus betulus* L.) with a share of 12.0%, Turkey oak (*Quercus cerris* L.) with a share of 11.1 %, black locust (*Robinia pseudoacacia* L.) with a share of 10.3%, Hungarian oak (*Quercus*

farnetto Ten.) with a share of 7.2%, sessile oak (*Quercus petraea* (Matt.) Liebl.) with a share of 6 , 1%, manna ash (*Fraxinus ornus* L.) with a share of 4,9%, Oriental hornbeam (*Carpinus orientalis* Mill.) With a share of 4,2% and field maple (*Acer campestre* L.) with a share of 2,2 %. Among conifer species, by a number of trees, the following species are the most common: Austrian pine (*Pinus nigra* Arn.) with a share of 4.0%, Norway spruce (*Picea abies* Karst.) with a share of 2.7% and Scots pine (*Pinus sylvestris* L.) with a share of 1.2% (Figure 4.2).

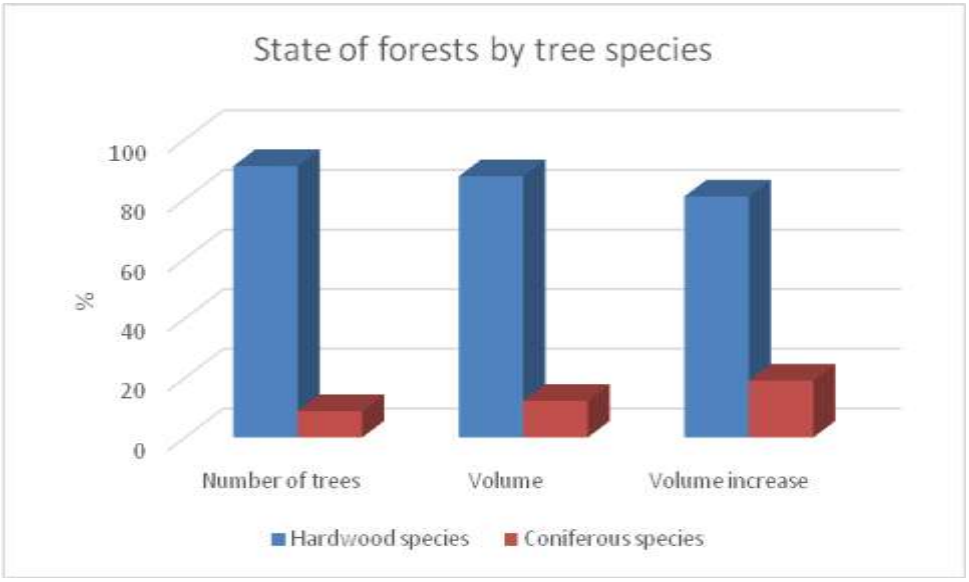


Figure 4.1. State of forests by tree species

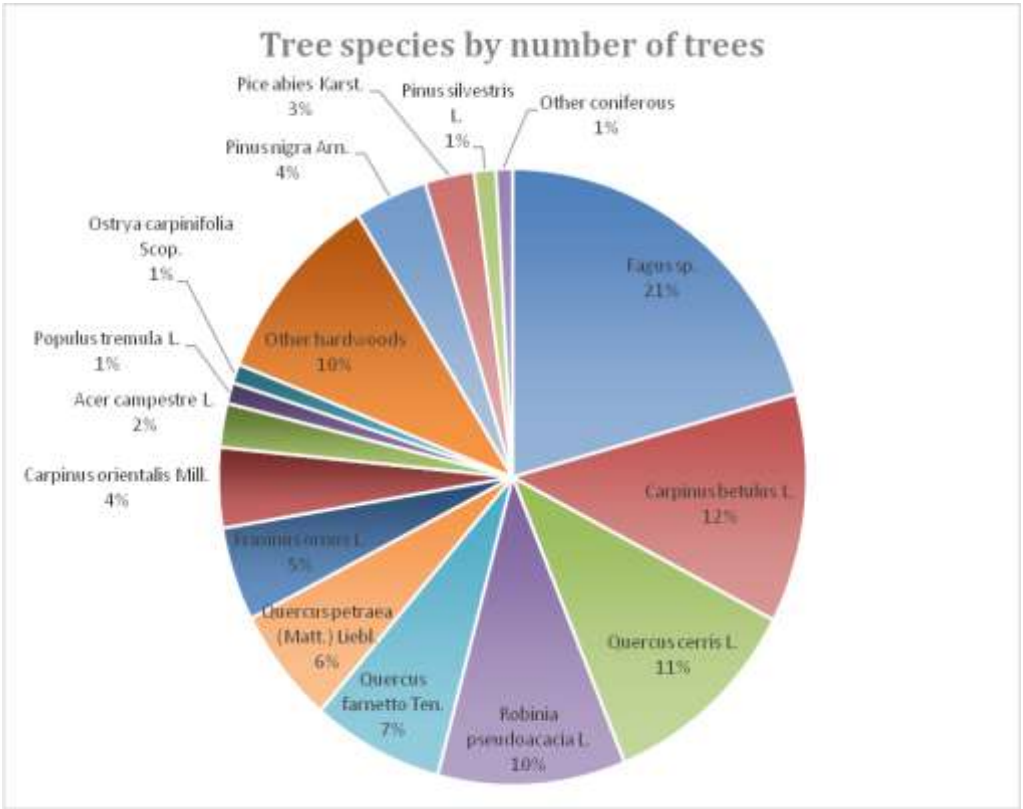


Figure 4.2. Tree species by a number of trees

In total volume, Serbia's forests are dominated by beech (*Fagus* sp.) with a share of 40.5%, and in volume increase with 30.6%, followed by Turkey oak (*Quercus cerris* L.) with 13.0% share in volume and 11.4% in volume increase, sessile oak (*Quercus petraea* (Matt.) Liebl.) with 5.9% share in volume and 6.1% in volume increase, Hungarian oak (*Quercus farnetto* Ten.) with 5.8% share in volume and 5.7% in volume increase, common hornbeam (*Carpinus betulus* L.) with 4.2% share in volume and 3.7% in volume increase, black locust (*Robinia pseudoacacia* L.) with 3.1% share in volume and 5.7% in volume increase, pedunculate oak (*Quercus robur* L.) with 2.5% share in volume and 1.7% in volume increase and narrow-leafed ash (*Fraxinus angustifolia* Vahl.) with 1.6% share in volume and 1.7% in a current volume increase.

Of the conifer species, Norway spruce (*Picea abies* Karst.) is the most prevalent species, accounting for 5.2% in volume and 6.7% by volume increase, Austrian pine (*Pinus nigra* Arn.) and Scots pine (*Pinus sylvestris* L.) in the total volume by 4.5% and the volume increase by 9.8%, while the silver fir (*Abies alba* Mill.) is present in the volume by 2.3% and in the volume increase by 2.2%. Clones of Euro-American poplars are present in volume with 1.7% and volume increase with 3.7%. Other species of trees have a share in the listed taxation elements of 1% or less, and accordingly, their sustainability is threatened and their ranking in management priorities is low.

Within forest genetic resources, forest fruit trees also play an important role. In Serbia, within the natural, primarily forest ecosystems, the presence of 122 species of fruit trees, classified into 23 families and 38 genera was recorded. In the autochthonous flora of Serbia are present the primers of apple varieties (*Malus sylvestris* (L.) Mill., *Malus florentina* Zuccagni and *Malus dasyphylla* Borkh.), pears (*Pyrus communis* L., *Pyrus amygdaliformis* Vill.), *plums* (*Prunus cerasifera* Ehrh., *Prunus spinosa* L.), cherries (*Prunus avium* L.), dwarf cherries (*Prunus fruticosa* Pall.), walnuts (*Juglans regia* L.), some almonds (*Prunus amygdalis* Mill.), hazelnuts (*Corylus avellana* L.), chestnuts (*Castanea sativa* Mill.), raspberries (*Rubus idaeus* L.), gooseberry (*Ribes grossularia* L.), red currants (*Ribes petraeum* Wulfen, *Ribes rubrum* L.), strawberry (*Fragaria vesca* L., *Fragaria viridis* Duchesne, *Fragaria moschata* Duchesne), etc. (Popović et al., 2017).

Number of introduced species managed or utilized in the forestry context

In addition to 250 indigenous tree species, a significant number of exotic (introduced species) are present in the forest fund of the Republic of Serbia. Of the introduced species, black locust (*Robinia pseudoacacia* L.) is the most prevalent, with a share of 10.3% in the total number of trees, followed by different poplar clones and cultivars, which are covered by the common name EA-poplars and are present in plantations, which essentially represent a separate constituent unit, with a share in the total number of trees of 0.3%. Intensive poplar plantations account for 1.7% of the total forested area of Serbia and 3.7% in a volume increase. An overview of the most significant introduced species, sorted by category, is presented in Annex 4.2. A number of these species are grown in forest cultures (planted forests) or they are present in seed stands. Also, some of these species exhibit an invasive or potentially invasive character and need special attention. The number of introduced species is certainly far greater if one considers the part of the inventory relating to parks, arboretums and other non-forest areas, in which these species enhance the aesthetic value, while enhancing the recreational equipment of the specific sites.

According to the experience in stand inventory and practical forest management planning in Serbia so far, relatively modest participation of exotic species in the total forest stock, expressed in area and volume, can be considered as favorable, except in the case of softwood plantations and plantations that participate in the total area and volume of Serbian forests with 1.7% and current volume growth with 6.3%.

Trends in the number of species in Serbia

According to Banković et al. (2009), in the forest fund of the Republic of Serbia, 12 species are marked as rare and endangered, 5 as rare, 9 as a relict, 6 as endemic, and 6 at risk (Table 4.1).

Table 4.1. Relict, endemic, rare and endangered species of forest trees and shrubs in Serbia

№	A species of trees and shrubs	Category
1.	Black alder - *Alnus glutinosa*	rare/endangered
2.	Silver poplar - *Populus alba*	rare/endangered
3.	Grey poplar - *Populus canescens*	rare
4.	Common walnut - *Juglans regia*	rare/endangered
5.	Wild cherry - *Prunus avium*	at risk
6.	European wild pear - *Pyrus pyraster*	at risk
7.	European crab apple - *Malus sylvestris, Pyrus malus*	rare/endangered
8.	Plum - *Prunus pseudoarmeniaca*	rare/endangered
9.	Wild service tree - *Sorbus torminalis*	at risk
10.	Rowan - *Sorbus aucuparia*	rare
11.	Whitebeam - *Sorbus aria*	at risk
12.	Aspen - *Populus tremula*	at risk
13.	Birch - *Betula pendula*	rare/endangered
14.	Turkish hazel - *Corylus colurna*	ter. relict
15.	Ash - *Fraxinus excelsior*	rare/endangered
16.	Pubescent oak - *Quercus pubescens*	rare/endangered
17.	Oak of Virgil - *Quercus virgiliana*	rare/endangered
18.	Montpellier maple - *Acer monspessulanum*	rare
19.	*Acer obtusatum*	subendemite
20.	*Acer intermedium*	endemite
21.	Norway maple - *Acer platanoides*	rare/endangered
22.	Heldreich's maple - *Acer heldreichii*	endemite
23.	Serbian spruce - *Picea omorika*	relict, endemite
24.	Balkan pine - *Pinus peuce*	endemite
25.	Bosnian pine - *Pinus heldreichii*	endemite
26.	Mugo pine - *Pinus mugo*	at risk
27.	European yew - *Taxus baccata*	ter. relict
28.	Field elm - *Ulmus minor*	rare/endangered
29.	Wych elm - *Ulmus montana*	rare
30.	European white elm - *Ulmus effusa*	rare/endangered
31.	European nettle tree - *Celtis australis*	endemite
32.	Spurge-laurel - *Daphne laureola*	relict
33.	Common holly - *Ilex aquifolium*	relict
34.	European hop-hornbeam - *Ostrya carpinifolia*	relict
35.	Cherry laurel - *Prunus laurocerasus*	relict
36.	European bladdernut - *Staphylea pinnata*	relict
37.	*Tilia caucasica*	relict
38.	Oriental plane - *Platanus orientalis*	rare

Source: Banković et al. (2009)

Trends in the number of species in the Forest Fund of the Republic of Serbia will only be possible to evaluate after the completion of a new forest inventory, which is ongoing, after which it will be possible to define trends in the number of individual species. What is evident is that negative activities in the recent and distant past have caused major changes in natural ecosystems, which have gradually led to the disappearance or decline of certain species of trees and shrubs, and their habitats have been destroyed or reduced to extremely small areas.

The global trend of a general decrease in the number of species did not bypass Serbia as well. The Republic of Serbia received the first Red Book in 1999 - the Red Book of Flora of Serbia 1, which refers to extinct and endangered plant species and contains 171 plant taxa (species and subspecies), accounting for about 5% of the total flora of the Republic of Serbia. Of these, four endemic taxa have been irreversibly lost from the world gene pool; 46 taxa have disappeared from the Republic of Serbia but can still be found in adjacent areas or in ex situ conditions (botanical gardens); 121 species are extremely endangered, with a high likelihood that they will disappear from our territories or the world soon if they are not given proper attention.

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

The drivers of changes in the number of species can be defined through the following pressures/ threats and their causes (Table 4.2).

Table 4.2. Overview of pressure/threats as drivers of changes in species number

Pressure / Threats	**Causes (*direct threatening factors*)**
Destruction, fragmentation and habitat loss	Conversion of native habitats for agriculture, forestry, housing, and commercial use
	Alteration of flow regimes of natural waterways
	Construction, use, and maintenance of the transportation infrastructure
	Deforestation and forest fires
	Overgrazing and lack of grazing
	Mining
	Tourism and recreation in nature
Environmental degradation and pollution	Pollution by pesticides
	Water pollution
	Air pollution
Global climate change	Temperature increase
	The occurrence of extreme weather events
Invasive and allochthonous species and GMO	Introduction of allochthonous species
	The transition of introduced species into invasive species
	Hybridization between invasive and native species
Overexploitation	Reduction of wild species populations
	Commercial exploitation
Pests and diseases	Outbreaks of pests and diseases

CHAPTER 5. STATE OF DIVERSITY WITHIN TREES AND OTHER WOODY PLANTS SPECIES

State and current technologies used for assessing the genetic diversity in trees

Assessment of intraspecific variability of forest trees in Serbia, using genetic markers, was performed for the most economically important species such as beech (*Fagus sylvatica* L.), sessile oak (*Quercus petraea* (Matt.) Liebl.), Scots pine (*Pinus sylvestris* L.), and Austrian pine (*Pinus nigra* J.F. Arnold), primarily to define the regions of provenance.

Intraspecific variability studies have also been performed on species that are significant in terms of conservation and direct use of the available gene pool, such as wild cherry (*Prunus avium* L.), Serbian spruce (*Picea omorika* (Panč.) Purkyne) and black poplar (*Populus nigra* L.). The studies conducted were performed at the test tree level representatives of population or maternal trees and their offspring in early tests established in a nursery or in the field.

Beech (*Fagus sylvatica* L.) is the most widespread and economically most important tree species in Serbia. At the same time it is a species of trees with the widest altitude distribution (from 40 to 2100 m above sea level) resulting from wide ecological amplitude in relation to climatic factors (light and heat) and edaphic factors (geological bedrock and soil types), and slightly lower amplitude relative to site humidity. Assessment of the genetic variability of beech within and between natural populations has been performed using morphological, anatomical, and molecular markers, in some studies conducted in the last ten years (Table 5.1).

Based on the results of the conducted research, the intraspecific variability of beech in Serbia was estimated (Ivetić, 2009), the regions of provenance for beech were defined, a total of 5 („Official Gazette of the Republic of Serbia" No. 15/10), to be redefined into 3 regions of provenance based on the latest research, conducted in 2019 (Ivetić, 2019). Assessment of genetic variability has also been the basis for defining the taxonomic position of beech in Serbia, which has been the subject of differing opinions of different authors for many years. The taxonomic status of beech in Serbia has been studied based on an assessment of variability among 15 natural populations of species representative, using morphological, anatomical and molecular markers, as well as in provenance trial established in Serbia at the "Majdanpekčka domena" Teaching Base, Faculty of Forestry - University of Belgrade. In this provenance trial, a total of 20 beech provenances were included: 5 Serbian, 5 Bosnian, 2 Croatian, 3 German, 2 Romanian, and one Hungarian, Austrian and Swiss each. Nuclear microsatellites have been used, which have been used in previous studies to analyze individuals from natural populations from Serbia. Besides, to increase the resolution for concluding the taxonomic status of beech trees in Serbia, additional molecular markers were used, including additional nuclear microsatellites as well as chloroplast microsatellites. Based on comprehensive studies of the genetic variability of beech (using the morphological, anatomical and molecular markers) at the level of natural populations in Serbia and comparison with different European provenances it is concluded that genetic profiles of beech populations from Serbia do not significantly differ from the genetic profiles of populations from Europe, which indicates that, based on the analyzed sample, beech in Serbia cannot be distinguished as a separate species.

Table 5.1. Overview of provenances used in studies of genetic variability within and between natural beech populations in Serbia

No.	Population/ provenance	altitude (m)	Markers	Source
1	Avala	475	Morphological, physiological, anatomical	Stojnić, 2013; Šijačić-Nikolić et al., 2017; Nonić et al., 2019
2	Besna Kobila 2	1132	RAPD	Ivetić, 2009
3	Besna Kobila 3	1220	RAPD	Ivetić, 2009
4	Besna Kobila 4	1250	RAPD	Ivetić, 2009
5	Bor	880	Proteins	Ivetić, 2009
6	Boranja	410	Morphological, physiological, anatomical	Stojnić, 2013, Šijačić-Nikolić et al., 2017; Nonić et al., 2019
7	Boranja	650	Nuclear microsatellites, chloroplast microsatellites	Šijačić-Nikolić et al., 2017, 2018
8	Boljetinska reka	670	Nuclear microsatellites	Nonić et al., 2015, Nonić, 2016
9	Bukovi	768	RAPD	Ivetić, 2009
10	Veliki Jastrebac 2	561	RAPD	Ivetić, 2009
11	Golija	860	RAPD	Ivetić, 2009
12	Golija	1300	Nuclear microsatellites, chloroplast microsatellites, anatomically	Šijačić-Nikolić et al., 2017, 2018; Jokanović et al., 2019
13	Goč	834	RAPD	Ivetić, 2009
14	Goč	870	Nuclear microsatellites, chloroplast microsatellites, anatomically	Šijačić-Nikolić et al., 2017; 2018, Jokanović et al., 2019
15	Goč-Gvozdac	910	Nuclear microsatellites	Nonić, 2016
16	Đerdap	540	Proteins	Ivetić, 2009
17	Žagubica	774	RAPD	Ivetić, 2009
18	Žagubica	460	Nuclear microsatellites, chloroplast microsatellites, anatomically	Šijačić-Nikolić et al., 2017, 2018; Jokanović et al., 2019
19	Zlotske šume	895	Nuclear microsatellites	Nonić, 2016
20	Zubin potok	1160	Proteins	Ivetić, 2009
21	Ivanjica	1250	Proteins	Ivetić, 2009
22	Istočna Boranja 2	870	RAPD	Ivetić, 2009
23	Javor	1534	RAPD	Ivetić, 2009
24	Javor	1350	Nuclear microsatellites, chloroplast microsatellites	Šijačić-Nikolić et al., 2017, 2018
25	Jadovnik	646	RAPD	Ivetić, 2009
26	Jošanička Banja	620	Proteins	Ivetić, 2009
27	Jastrebac	1150	Nuclear microsatellites	Ivetić, 2019
28	Jelova gora	950	Nuclear microsatellites	Ivetić, 2019
29	Kopaonik	820	Morphological, physiologically, anatomically, Nuclear microsatellites	Stojnić, 2013; Šijačić-Nikolić et al., 2017, Jokanović et al., 2018; Nonić et al., 2019, Čortan et al., 2019
30	Kopaonik	1000	Nuclear microsatellites, chloroplast microsatellitesи, anatomically	Šijačić-Nikolić et al., 2017, 2018; Jokanović et al., 2019
31	Kopaonik 1	1580	RAPD	Ivetić, 2009
32	Kopaonik 2	1097	RAPD	Ivetić, 2009
33	Kukavica	1060	Nuclear microsatellites, chloroplast microsatellites, anatomically	Šijačić-Nikolić et al., 2017, 2018; Jokanović et al., 2019

No.	Population/ provenance	altitude (m)	Markers	Source
34	Kukavica 1	731	RAPD	Ivetić, 2009
35	Kukavica 2	985	RAPD	Ivetić, 2009
36	Kukavica 3	1041	RAPD	Ivetić, 2009
37	Kukavica 5	1122	RAPD	Ivetić, 2009
38	Miroč	286	RAPD	Ivetić, 2009
39	Miroč	500	Nuclear microsatellites, chloroplast microsatellites, anatomically	Šijačić-Nikolić et al., 2017, 2018; Jokanović et al., 2019
40	Murtenica	1348	RAPD	Ivetić, 2009
41	Pirot	1050	Proteins	Ivetić, 2009
42	Radan	635	RAPD	Ivetić, 2009
43	Rogozna	865	RAPD	Ivetić, 2009
44	Rtanj	728	RAPD	Ivetić, 2009
45	Rudnik	637	RAPD	Ivetić, 2009
46	Rudnik	850	Nuclear microsatellites, chloroplast microsatellites	Šijačić-Nikolić et al., 2017 Šijačić-Nikolić et al., 2018
47	Senjski Rudnik	920	Nuclear microsatellites, chloroplast microsatellites, anatomically	Šijačić-Nikolić et al., 2017, 2018; Jokanović et al., 2019
48	Stara Planina	917	RAPD	Ivetić, 2009
49	Stara Planina	800	Nuclear microsatellites, chloroplast microsatellites, anatomically	Šijačić-Nikolić et al., 2017, 2018; Jokanović et al., 2019
50	Tara	1089	RAPD	Ivetić, 2009
51	Tara	1075	Nuclear microsatellites, chloroplast microsatellites, anatomically	Šijačić-Nikolić et al., 2017, 2018; Jokanović et al., 2019
52	Fruška gora	370	Morphological, physiologically, Nuclear microsatellites, anatomically	Stojinic et al., 2010; Stojnić, 2013; Šijačić-Nikolić et al., 2017; Jokanović et al., 2018; Nonić et al., 2019; Čortan et al., 2019
53	Fruška gora	300	Nuclear microsatellites, chloroplast microsatellites, anatomically	Šijačić-Nikolić et al., 2017, 2018; Jokanović et al., 2019
54	Cer	745	Morphological, physiological, anatomical, Nuclear microsatellites	Stojnić, 2013; Šijačić-Nikolić et al., 2017; Nonić et al., 2019
55	Cer 1	644	RAPD	Ivetić, 2009
56	Cer 2	645	RAPD	Ivetić, 2009
57	Crni vrh 2	480	Nuclear microsatellites	Nonić, 2016

Beech genetic variability was also assessed at the level of two provenance trials, established within the European Network of Provenance Trials. Studies have been carried out successively at different stages of ontogeny, using morphological (Šijačić-Nikolić et al., 2012, 2013; Nonić et al., 2019; Čortan et al., 2019), physiological (Stojnić et al., 2010, 2012, 2013), anatomical (Stojnić, 2013; Jokanović et al., 2018, 2019), and molecular markers.

Oaks (*Quercus sp.*) are the most represented tree species in the forests of Serbia, after beech. In addition to its distribution by species number, oaks are one of the most important systematic groups in the dendroflora of Serbia.

Due to the great economic importance of the sessile oak (*Quercus petraea* agg. Ehrendorfer 1967) and its populations, as well as the high degree of vulnerability due to the effects of drought, studies of its ecological-genetic variability in Serbia were performed, which served as a basis for defining of the provenance region, a total of 2 („Official Gazette of the Republic of Serbia" No. 91/08).

Based on the climatic, edaphic and phytocenological characteristics of the localities where oak forests have been recorded in Serbia, eight gene-ecological zones were preliminary identified: Vojvodina, Northwestern Serbia, Sumadija, Northeast Serbia, East Serbia, Southeast Serbia, West and Southwestern Serbia and Central Serbia. These gene-ecological zones were the starting point for the collection of plant material for laboratory analyzes at the level of molecular markers. A total of 96 samples were included in the analyzes, representing 32 populations at 20 different localities, including horizontal and vertical zoning of *Quercus petraea* in Serbia.

The genetic variability of sessile oak (*Quercus petraea agg*. Ehrendorfer, 1967) in Serbia has been determined using universal primer pairs of chloroplast DNA, characterized by a high degree of informativeness for evaluating chloroplast genome variability in previous studies. Five different sessile oak haplotypes from populations in the territory of Serbia were detected in the analyzed material (Milovanović, 2009; Šijačić-Nikolić et al., 2009, 2009a, 2009b; Milovanović, Šijačić-Nikolić, 2010).

The results of molecular analyzes showed that the regions of the gene-ecological zones of Vojvodina, Northwestern Serbia, Sumadija, Northeast, East, Southeastern and Central Serbia can be combined into one region (Region I), since the presence of only one haplotype in all sampled populations from these zones (haplotype 1).

The gene-ecological zone of Western and Southwestern Serbia, including the entire range of altitudes in which seesile oak populations are present, is defined as a separate region (Region II), since rare haplotypes 2, 3, 4 and 5 are present in addition to haplotype 1. This conclusion is confirmed by the ecological characteristics of the sessile oak sites in this region, which are characterized by the specific geological basis (serpentinite, serpentinized peridotite, and peridotite), as well as three different types of climate (humid low forests climate, humid high forests climate, and moist perhumic climate). Based on the above, it was concluded that the gene-ecological zone of Western and Southwestern Serbia, by ecological-genetic characteristics, is specific and is a clear proof of the complex cause-effect of interaction between genotype and environment.

The variability between populations of **Scots pine (*Pinus sylvestris* L.) and Austrian pine (*Pinus nigra* Arn.)** was determined using seed protein markers. The studies included 7 populations of Scots pine and six populations of Austrian pine, which were evenly distributed within the range of these species in Serbia. The results obtained from the analysis of seed protein similarity indexes of the studied populations of Scots pine showed variability ranging from 0.47 to 0.87 while variability in Austrian pine in the range from 0.64 to 0.95. This indicates that there is greater genetic variability between the analyzed populations of Scots pine than is the case of Austrian pine populations. Also, the obtained results indicate a strong influence of geographical distance and isolation of populations on genetic differentiation as well as the existence of significant genetic variability, between both Scots pine and Austrian pine populations (Lučić et al., 2008; Lučić et al., 2010).

Additional study of Austrian pine populations' variability in Serbia was performed on ecological-genetic grounds (Lučić, 2011). Environmental studies included analysis of site characteristics of selected populations, while genetic characterization of the starting populations was performed based on seed protein polymorphism and seed DNA polymorphism using SSR (Simple Sequence Repeats) markers.

Wild cherry (*Prunus avium* L.) is one of the most important species of autochthonous flora of forest fruit trees in Serbia. As such, it is a significant source of germplasm and exploring the available gene pool is the starting point for its conservation and continued targeted use.

The assessment of the genetic variability of wild cherry in the territory of Serbia was conducted using morphological and molecular markers. The research included 9 natural populations that are evenly distributed within the range of the species: Fruška gora, Javor, Šumarice, Lipovica, Vlasina, Tresibaba, Djerdap, and Mačkov Kamen. The analysis of morphological characteristics of leaves included the following characteristics: leaf area, leaf circumference, and leaf width at the widest part, leaf width at 25% of length, leaf width at 75% of length, leaf length, petiole length, and number of lateral nerves on the right side of the leaf. Populations showed statistically significant differences for all observed leaf morphological characteristics. As the most heterogeneous populations, the populations of Vlasina, Tresibaba, and Djerdap stand out according to morphological characteristics. The Mačkov Kamen population is at a significantly greater distance than the other 8 populations. Based on the obtained results, it was concluded that in the studied populations a high degree of variability of the investigated morphological characteristics of leaves is present (Kerkez et al., 2015; Kerkez, Popović, 2016).

Genetic characterization of natural populations was also performed using microsatellite molecular markers (SSRs). Based on the results of the analysis of molecular variance (AMOVA), intra-population variability (31%) is greater than inter-population (8%). The obtained results only confirmed the existence of a significant degree of genetic variability among the analyzed populations of wild cherry in Serbia, which was determined using morphological markers (Kerkez, 2016).

Black poplar (*Populus nigra* L.) is one of the most significant species of forest tree alluvial habitats in Europe, which in recent years has faced serious threats to its survival, primarily due to the loss of its habitats and the impossibility of natural regeneration.
The assessment of the intraspecific variability of the black poplar in Serbia was performed in the area of Vojvodina, in part of its natural range, along the streams of the three largest rivers: the Danube (upper and lower streams), the Sava and the Tisza. Four populations were selected for research, representing the remnants of former natural populations of this species: upper Danube stream (locality Bački Monoštor); Tisa (Titel locality), Sava (Klenak locality) and lower Danube flow (Kovin locality).

Genetic variability within and between populations was assessed using three types of genetic markers: morphological, anatomical, and molecular (SSR). Analyzes at the level of morphological markers included 9 baselines (leaf length and width, petiole length, the angle between first nerve and horizontal, leaf width at 1 cm from the top of leaf, distance between leaf base and widest part of leaf, length of whole leaf, number of nerves with left

side of the leaf, number of nerves on the right side of the leaf) and three derived leaf characteristics (ratio of leaf width and length, leaf width and leaf length, base distance to the widest part of leaf and leaf length) (Čortan et al., 2014, 2015a; Čortan, 2015).

Using anatomical markers, five basics (stomata density, stomata dimensions - length and width of the closure cells and stomatal opening) were analyzed and three derived characteristics of the leaf stomata (stomata shape coefficient, potential stomata permeability index, facial stomata density ratio of upper and back surface) (Čortan, 2015; Čortan et al., 2015, 2017), while twelve microsatellite markers were used to assess neutral variability (Čortan, 2015; Čortan et al., 2016). The results obtained indicate significant variability within populations and small variability among analyzed populations.

The intra-population variability of the black poplar was also studied at the level of an isolated natural population located on the Great War Island, in the Danube River in the part that flows through Belgrade. Variability was studied at the test tree level of population-representative trees, using morphological and molecular markers. Morphological analyzes were performed on leaves of test trees, while the genetic structure of the population was studied using microsatellite molecular markers (SSRs). The obtained results indicate a satisfactory degree of genetic variability within the analyzed population (Maksimović et al., 2013, 2014, Maksimović, 2015).

Serbian spruce (*Picea omorika* Punch/Purkyne) is an endemic of the Balkan Peninsula and a relic from the Tertiary era. Today, it is found only in the Balkans, in the narrow area around the middle and upper stream of the Drina River, at the border of eastern Bosnia and Herzegovina and western Serbia.

The genetic structure of the Serbian spruce in Serbia was investigated at the level of a generative seed orchard established in the village of Godovik near Požega (1986). The orchard is based on 5959 different genotypes that originate from 50 lineages of half-sibs of different phenogroups, from three cultures: Bela Zemlja, Popova Luka and Šargan, based on reproductive material from natural populations from Tara Mountain (Crvena Stena site). To investigate the genetic structure of different half-sib lines used for the establishment of the seed orchard, morphological analysis of quantitative traits, analysis of regularity and abundance of flowering, quality and quantity analysis of crop and biochemical analysis at the level of protein markers, as a basis for selection of parental individuals to conduct controlled hybridization were performed (Šijačić-Nikolić, 2000, 2004; Šijačić-Nikolić, Isajev, 2004).

The variability of the genetic structure of Serbian spruce, at the level of different fenogroups from the generative seed orchard, was determined based on: morphological characteristics of the needles (length, width and mass of needles); anatomical characteristics of the needles (thickness of the needles, width of the vessels, and diameter of the resin channels) and three types of molecular markers: isoenzymes, mitochondrial DNA and SSRs. The results obtained show a significant genetic distance between the analyzed phenogroups as well as a degree of differentiation between them, although phenotypic expression cannot be characterized as strictly genetically controlled (Milovanović et al., 2004; Milovanović, 2007).

In addition to the studies described here, there are ongoing investigations of intraspecific variability of narrow-leafed ash (*Fraxinus angustifolia* Vahl.) from natural populations in the Upper Danube region and pedunculate oak (*Quercus robur* L.) from natural populations in the area of Srem. These investigations are important because gene pool of these species in Serbia is seriously endangered.

Trends in the genetic diversity of these species and in the state of their populations

Genetic variability of tree species in Serbia has been studied for a relatively small number of species, at partial portions of their distribution, and the research conducted does not have a continuous character to be able to assess for sure the variability trends for most of them.

The diversity of most species in Serbia are confronted with many factors that threaten them: forest destruction and fragmentation, pollution, allochthonous and invasive species, inappropriate use of forest reproductive material, the effects of inadequate practice, the spread of pests and diseases, abiotic factors (droughts, forest fires, icebreakers, snow, windbreaks), water regime and climate change. All these factors have the effect of reducing natural populations, which also results in the loss of genetic variability within the species themselves.

The trend of variability for beech (*Fagus sylvatica* L.) is the best studied. Research has been continuous for recent decades. Variability was estimated at close to 60 populations/provenances from the entire territory of Serbia, using different genetic markers (morphological, anatomical, and molecular). Based on the results of the conducted research, it can be concluded that there is a satisfactory degree of genetic variability of this species, which can be characterized as stable but under significant pressure of climate change, which is also the case with other native species of trees.

The decline of genetic diversity can be noted for some species that are characterized as relict, endemic, rare and / or endangered in the forest fund of the Republic of Serbia. Banković et al. (2009) state that according to the IUCN categorization, there are 38 species of trees and shrubs from these categories present in the forests of Serbia, of which 12 are rare and endangered, five are rare, nine are forest species are relict, six are endemic and six represent species at risk (see Chapter 4).

A drastic example of declining genetic diversity has been observed in Serbian spruce (*Picea omorika* Panč./Purkyne), which is registered in Serbia in only about twenty smaller isolated populations or groups of trees. Natural populations of the Serbian spruce have been protected by law since 1964, and the species has been listed in the IUCN Red List of Endangered Plants since 1997. Competition, poor natural regeneration, and fires remain the major threats for Serbian spruce populations. Dieback induced by climate change is a new threat whose severity for Serbian spruce is much higher than for some other tree species because of the small size of its populations and lack of natural regeneration (Ivetić, Aleksić, 2016).

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

The availability of information on the genetic variability of tree species in Serbia is relatively limited and is not systematically presented in one place. Most of the information on the genetic diversity of individual tree species are found in scientific research papers published in national and international journals or reports on the implementation of various projects.

Bearing in mind the importance of knowledge of genetic diversity as a basis for the conservation of forest genetic resources and breeding activities, there is a need to collect, consolidate and systematize available data in one place, which could be implemented internationally as one of the activities within the European Forest Genetic Resources Program.

At the national level, integrated information on the genetic diversity of forest trees could be made available through a website set up by the *Center for Monitoring and Conservation of Forest Genetic Resources*, which exists at the University of Belgrade - Faculty of Forestry. The Center aims to raise the level of knowledge about forest genetic resources, the need for their monitoring and conservation, including activities to assess the genetic diversity of forest trees, primarily endemics, relics, and endangered species. Such activities require the support of relevant institutions through project activities, promotion, and education of the wider community.

Increasing the visibility of the information on the genetic diversity of forest trees as well as their accessibility to the general public is possible through the following activities:

1. Systematization of available information on genetic diversity of individual tree species in the territory of Serbia;
2. Establishment of a website where all existing information on genetic variability at the level of different species of trees would be available;
3. Establishing research priorities for assessing the genetic variability of the most endangered or economically significant tree species;
4. Improvement of program frameworks for project activities related to the assessment of the genetic variability of woody species and the continuation of the initiated research;
5. Providing significant sources of funding for project activities towards assessing the degree of genetic variability of forest trees as a basis for gene pool conservation and breeding programs;
6. Strengthening of state, public and private sector capacities in the field of forest genetic resources and their diversity, which can be achieved through long-term training programs for state, public and private forestry representatives, as well as to prepare educational materials and improve the knowledge of public administration employees and public companies, as well as private forest owners, on the need to align forest management with forest genetic resource conservation goals.

PART 3

STATE OF FOREST GENETIC RESOURCES CONSERVATION

CHAPTER 6. *IN SITU* CONSERVATION OF FOREST GENETIC RESOURCES

Approaches used for in situ conservation

In situ (on site) conservation of forest genetic resources is most often applied in Serbia in natural populations which are naturally regenerated in protected areas (national parks, nature parks, landscapes of outstanding features, nature reserves, protected habitats, natural monuments, areas of cultural and historical importance) and in forests which are regularly managed. Conservation of forest genetic resources in forests managed on a regular basis is mainly realized through designating seed facilities (seed stands, groups of trees or individual trees). This form of forest genetic resources conservation is most frequently the only sustainable form since the financial resources allocated for conservation are modest.

Conservation of forest genetic resources in the protected areas

Currently, the area of protected areas is 677,950 ha, i.e. 7.66% of the territory of Serbia. There are 469 protected areas (January 2020), namely: 5 national parks, 18 nature parks, 21 landscapes of outstanding features, 69 nature reserves, 6 protected habitats, 314 natural monuments, 36 sites of cultural and historical significance (INC, 2020a). The Spatial Plan of the Republic of Serbia (SPRS, 2010), envisages that 10% of the territory of Serbia would be under protection until 2015 and 12% until 2021 (OECD, 2014).

Protected areas represent significant form of *in situ* conservation of forest genetic resources because large areas of forest complexes are located in them (Milovanović, Šijačić-Nikolić, 2007, 2010; Šijačić-Nikolić et al., 2014; 2014a, 2017). Within the forest complexes which are under different protection regimes, cultivation measures have been implemented which are in line with the laws in the area of forestry, nature, and environmental protection.

The importance of the protected areas in conservation and directed use of forest genetic resources depends on the participation of forest ecosystems in their total area. Considering the participation of forest areas in the total area of active protection of national parks in Serbia, diversity of forest ecosystems in them, and a large number of described endemic and relict species, it is clear that national parks represent the significant basis for conservation and directed use of forest trees gene pool *in situ*, in habitats where the species naturally occur (Šijačić-Nikolić et al., 2006).

There are five national parks (NP) in Serbia: NP „Fruška gora", NP „Djerdap, Tara, Kopaonik, and Šar-planina. The total area of national parks is 158,986.36 ha, i.e. 1.75% of the territory of Serbia. Their total values exceed the borders of our country. Therefore, they are included in the Federation of Nature and National Parks of Europe „EUROPARC". The oldest national park in Serbia is Fruska Gora, declared a national park in 1960. The largest is NP „Djerdap", and the smallest NP „Kopaonik".

National Park „Fruška gora" is located in the heart of the Pannonian Plain. It covers an area of active protection of 25,525 ha. More than 1,400 species have been recorded in the Fruska Gora flora, among which relict and endemic species stand out such as *Daphne blagayana*, pheasant's eye (*Adonis vernalis*), pygmy iris (*Iris pumila*) and more than 20 species from the orchid family (*Orchidaceae*). Forest communities are mixed or pure and they cover 90% of the total area.

There are monodominant forests of sessile oak, beech, and somewhere linden or common hornbeam, while in the composition of bidominant forests linden and beech are most often involved, and less often hornbeam and sessile oak. Pure beech forests, as well as pure hornbeam forests, are rare. The Climatic-zonal type of the forest on Fruska Gora is sessile oak and hornbeam with butcher's-broom. Besides the above, communities of beech and linden have a significant place in the vegetation of broadleaved forests (INC, 2020/b).

National Park „Kopaonik" is situated in the central part of Serbia. With its area of 11,810 ha it comprises the highest parts of this mountain massif bordering with river valleys of Ibar, Josanica, Toplica, and Brzecka Reka. So far, 1,500 plant species have been described in the flora of Kopaonik, 91 of which are endemic and 82 sub endemic, which indicates that this area is one of the most important centers of biological diversity and endemism of Serbia and the Balkans in general. Three local endemics, the Kopaonik houseleek (*Sempervivum tectorum*), the Kopaonik violet (*Viola kopaonikensis*), and Pančić's bittercress (*Cardamine pancicii*) have a special place in this abundance. The scattered forest and pasture zone of central Serbia is the most widespread on Kopaonik. There is a coniferous forest of Norway spruce and fir on higher parts and beech and oak forest on the sides (INC, 2020/c).

National park „Tara" with its area of 19,200 ha covers the largest part of Tara mountain which extends at the far west of Serbia and includes the area bordering with the Drina river between Visegrad and Bajina Basta. Forest ecosystems cover about 70% of its total territory, so its importance for the conservation of forest genetic resources is immeasurable. This area is a forest area, which in terms of diversity and conservation is one of the richest and most valuable forest areas in Europe, with more than 1,000 plant species. Numerous forest phytocoenoses of very complex composition, floristically very rich, with a number of relict and endemic species of plants have been hiding real natural rarities such as Serbian spruce (*Picea omorika*), yew (*Taxus bacata*), holly (*Ilex aquifolium*), *Daphne blagayana*, rustyback (*Asplenium ceterach*), *Cyclamen*, willow gentian (*Gentiana asclepiadea*), etc. The sites with these species indicate that many parts of Tara, gorges and canyons above all, are unique mountain habitats where many communities of relict habitats have been conserved in full or to a greater extent until present with their original primordial characteristics. Tertiary vegetation with phytocoenoses of primeval forest character and very rich and complex composition has been conserved in those communities. Mixed forest community of fir, beech and Norway spruce with individual specimens or smaller groups of other conifers such as Scots pine (*Pinus sylvestris*) and Serbian spruce (*Picea omorika*) and broadleaved tree species such as sycamore (*Acer pseudoplatanus*), aspen (*Populus tremula*), silver birch (*Betula pendula*), and others are predominant on Tara mountain. Due to its abundance of species, the Tara complex represents real living archive of flora typical of a large part of Balkan Peninsula and a gene pool reserve significant at the European and global levels (INC, 2020/d).

National Park „Djerdap" comprises an area of 63,680 ha, 44,851 of which are forests (Medarević, 2005). It stretches along Djerdap Gorge on the right bank of the Danube River, for about 130 km, between towns of Golubac and Kladovo. The flora of Djerdap is characterized not only by its great diversity and abundance but also by its distinct relict character. More than 11,000 plant species are described in the area of the park, among which the especially significant species are tertiary relicts, woody species that survived the ice age and persisted until today: Turkish hazel (*Corylus colurna*), common walnut

(*Juglans regia*), European bladdernut (*Staphylea pinnata*), Montpellier maple (*Acer monspessulanum*), lilac (*Syringa vulgaris*), European nettle tree (*Celtis australis*), green olive tree (*Phillyrea latifolia*) and yew (*Taxus bacata*). Nowadays in the Djerdap Gorge ancient relict species live together with expansive postglacial types of species such as: oak, maple, ash, elm, linden, hawthorn, hornbeam, etc. Together with the above relict species they make unique and unrepeatable arboretum of the Djerdap Gorge in which the history of flora from the tertiary period to the present day is recorded. A total of fifty forest and shrub communities are singled out in this area, 35 of which are of relict character (INC, 2020/e).

National Park „Šar-planina" spreads in the southernmost part of Serbia, along the border with North Macedonia in the area of 39,000 ha. It is one of the most important biodiversity centers in the Balkan Peninsula. It comprises about 56% of the flora of Serbia with about 2,000 species of vascular plants and 20 local endemic species of Sar Planina among which the best known are Serbian phoenix flower (*Ramonda serbica*), Macedonian pine (*Pinus peuce*), Bosnian pine (*Pinus heldreichii*) and Macedonian oak (*Quercus trojana*). Forests of oak, beech, mixed forests of beech and fir, as well as spruce and fir, spread up to the belt of Macedonian pine and Bosnian pine forests which form the upper forest border (INC, 2020/f).

The program of in situ conservation of forest genetic resources

Singling out seed stands is the most frequently applied form of *in situ* conservation of forest genetic resources in Serbia. According to the data from the current Register of Seed Facilities of the Ministry of agriculture, forestry and water management of the Republic of Serbia – Directorate of Forests (DOF, 2020) 139 seed facilities of autochthonous forest tree species have been singled out in Serbia in the total area of 1443.7 ha, 37 of which are seed facilities of coniferous trees, 100 are seed facilities of broadleaved species and two mixed seed stands. Forest species included in *in situ* conservation programmes in Serbia are presented in Table 6.1.

The current number and area of seed stands are insufficient and do not reflect the abundance of gene pool of our country's forest tree species, to which special attention should be paid in the coming period.

To ensure the proper use of seeds from seed stands, according to Article 9 of the Law on Reproductive Material of Forest Trees (OG, 2004a), the Minister of agriculture, forestry and water management issued decisions on establishing regions of provenance for the following forest tree species: **beech (5, redefined to 3)** („Official Gazette of the Republic of Serbia", no. 15/10), **sessile oak (2) and common oak (2)** („Official Gazette of the Republic of Serbia", no. 91/08), **Austrian pine (3)** („Official Gazette of the Republic of Serbia", no. 55/09), **Scots pine (2)** („Official Gazette of the Republic of Serbia", no. 83/10), **narrow-leafed ash (2), spruce (3) and fir (3)** („Official Gazette of the Republic of Serbia", no. 79/09). For all other forest tree species, the whole territory of the Republic of Serbia represents one region of provenance. Regions of provenance are a legal prerequisite for trade and use of forest reproductive material of the „known origin" category since this reproductive material can be used for afforestation only in the region of provenance where it was produced so that afforestation is carried out by reproductive material adapted to environmental conditions of the area in which it is used. It also ensures conservation and directed use of gene pool on site (*in situ*) within the region of provenance.

Table 6.1. Forest species included in *in situ* conservation programmes

Species	Number of objects	Area (ha)
Gymnospermae		
Abies alba Mill.	8	84.84
Picea abies (L.) Karst.	15	119.93
Picea omorika (Panč.) Purkyne	1	4.74
Pinus nigra Arn.	8	86.94
Pinus sylvestris L.	5	24.54
Total *Gymnospermae*	37	320.99
Angiospermae		
Acer heldreichii Orph.	1	0
Acer platanoides L.	2	4.02
Acer pseudoplatanus L	7	19.52
Betula pendula Roth.	2	0
Carpinus betulus L.	1	50.37
Castanea sativa Mill.	1	0.18
Corylus colurna L.	5	0.88
Fagus sylvatica L.	20	171.07
Fraxinus excelsior L.	5	0.25
Fraxinus angustifolia Vahl.	2	19.2
Juglans regia L.	1	0
Prunus avium L.	6	0
Quercus frainetto Ten.	9	145.28
Quercus petraea Liebl.	13	63.13
Quercus robur L.	16	607.43
Sorbus aucuparia L.	1	0
Sorbus torminalis (L.) Crantz.	1	0
Tilia tomentosa Moench.	2	1.9
Tilia platyphyllos Scoop.	2	0
Ulmus montana With.	3	0.08
Quercus robur L., *Fraxinus excelsior* L.	1	29.78
Fagus sylvatica L., *Abies alba* Mill.	1	9.62
Total *Angiospermae*	102	1122.71
Total *Gymnospermae* + *Angiospermae*	**139**	**1443.7**

Organization of in situ conservation efforts at national (or subnational) level(s), including main players and stakeholders

There are no organized *in situ* conservation programs in Serbia, but it can be said that they are implemented through the designation of seed sources, which are regular activities of public enterprises for forest management, national parks, forest-owners, and users of forests. The process consists of candidacy, evaluation, and registration of seed sources at the competent ministry. This process is continuous, and the Register of seed sources is regularly updated.

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

- ✓ Weakness: Insufficient financial resources.
  Priority objectives: To improve the current status of *in situ* conservation of forest genetic resources it is necessary to provide special-purpose financial resources for *in situ* conservation programme on the national level in the appropriate period.
- ✓ Weakness: Insufficient knowledge and information on the effect of the factors endangering forest genetic resources.

Priority objectives: To identify rare and endangered species that are priorities for conservation and prepare a plan of adequate conservation measures; To align forest tending with the conservation of forest genetic resources and define clearly the procedures for the selection of a type of felling as a tending measure; To develop long-term *in situ* conservation programme for phenotypically most valuable trees, very old trees, as specimens with distinct adaptive potential; To influence on the reduction of deforestation and forest fragmentation using preventive measures, strict legal regulations, and adequate punitive measures.

- ✓ Weakness: The lack of planning documents for forest genetic resources in situ conservation programmes on the national and local levels.
  Priority objectives: It is necessary to convert the National program for conservation and sustainable utilization of FGR of the Republic of Serbia for the period 2016-2025 (draft) into a binding document; To develop long-term forest genetic resources *in situ* conservation programme.
- ✓ Weakness: There is no organized and regular monitoring of the status of *in situ* conservation units on the national level.
  Priority objectives: It is necessary to establish monitoring of *in* situ conservation areas on the level of state and companies entrusted with the management of resources which will become a basis for planning conservation measures; It is necessary to establish the network of *in situ* conservation areas on the national level.

Priorities for capacity building and research in this area

For measures and priorities for forest genetic resources *in situ* conservation to be proposed based on real status, future research activities should be following the National program. All this should be followed by necessary capacity building.

The capacity building and training of individuals engaged in forest genetic resources *in situ* conservation should be conducted through the following activities:

1. Development of an integrated approach to building and strengthening capacities for *in situ* conservation of forest genetic resources through the building of institutional, social and individual capacities;
2. Development of national program and center for training of public and private sector for forest genetic resources *in situ* conservation;
3. Development of consulting service for the field of forest genetic resources *in situ* conservation;
4. Provision of education and training of individuals engaged in the implementation of forest genetic resources *in situ* conservation programme using various courses and workshops (for addressing specific priority issues in this field);
5. Preparation and publication of manuals on the manner of implementation of specific forest genetic resources *in situ* conservation measures, which will be available and friendly for forest owners and users.

CHAPTER 7. *EX SITU* CONSERVATION OF FOREST GENETIC RESOURCES

State of ex situ conservation efforts

Ex situ conservation of forest genetic resources in Serbia is performed by establishing seed orchards, progeny tests, and provenance trials, clonal archives, genetic collections of different tree species (Table 7.1).

Table 7.1. *Ex situ* conservation of forest genetic resources in Serbia

Species	Seed orchards	Progeny tests	Provenance trials	Clonal archives	Genetic collections
Picea abies (L.) Karst.			X		
Picea omorika (Panč.) Purkyne	X				
Pinus nigra Arn.	X				
Pinus sylvestris L.	X				
Pinus peuce Griseb.		X			
Pseudotsuga menziesii (Mirb.) Franco			X		
Acer heldreichii Orph.	X				
Fagus sylvatica L.			X		
Fraxinus angustifolia Vahl	X	X			
Prunus avium L.	X				X
Quercus robur L.	X	X			
Populus sp.		X		X	
Salix sp.				X	
Ulmus laevis Pall.		X			

Seed orchards

To date, 10 special-purpose objects have been established in Serbia, for transformation into seed orchards and its registration: 2 vegetative objects of pedunculate oak (*Quercus robur* L.) and 2 of wild cherry (*Prunus avium* L.); 1 generative object of: pedunculate oak (*Quercus robur* L.), Balkan maple (*Acer heldreichii* Orph.), Serbian spruce (*Picea omorika* (Pančić) Purk.), Austrian pine (*Pinus nigra* Arn.), Scots pine (*Pinus sylvestris* L.), and narrow-leafed ash (*Fraxinus angustifolia* Vahl). From these objects, so far, only 3 received the status of registered seed orchards, as follows: 1 of Serbian spruce (*Picea omorika* (Pančić) Purk.) at 2.7 ha and 2 of pedunculate oak (*Quercus robur* L.) in a total area of 16.81 ha.

Seed orchards of pedunculate oak have been established in the area managed by Public enterprise „Vojvodinašume", Forest Estate (FE) „Sremska Mitrovica". Clonal seed orchards have been established in forest management units (FMU) „Banov Brod" and „Visoka Šuma-Lošinci", while generative seed orchard has been established in FMU „Jalija-Leget-Turijan". The following varieties of pedunculate oak are represented in seed orchards: early (*Q. robur* var. *praecox*), typical (*Q. robur* var. *typica*) and two varieties of late pedunculate oak (*Q. robur* var. *tardiflora* and *Q. robur* var. *tardissima*) (Orlović et al., 2002).

Generative seed orchard of Balkan maple was established in 1994 in the area of FE „Golija" Ivanjica. Seeds of Balkan maple have been collected from 26 trees from natural populations that have been selected based on above-average morphological (technical) and physiological (abundance and regularity of seed yield) characteristics (Isajev et al., 1994). The area of the seed orchard is 1.05 ha, with the total number of 2692 plants. The distribution of seedlings within the blocks is based on the so-called metapopulation model (Tucović, Isajev, 1991).

After years of studying genetic variability of Serbian spruce, generative seed orchard was established in 1987. It was erected in the area of 2.73 ha, near Godovik village, in the vicinity of Požega. It consists of 50 half-sib lines, while the total number of genotypes in the seed orchard amounts to 5959 (Isajev, Šijačić-Nikolić, 2001, 2003, 2003a).

The seed orchard of Austrian pine was established in 1991 in FMU „Jelova Gora". It consists of 5422 genotypes of 40 half-sib lines, originating from Šargan - Mokra Gora and Crni Vrh - Priboj seed stands (Vukin, Isajev, 2004). The altitude of the seed orchard is 920 m and it is exposed to south-southeast. The habitat where the object is located belongs to the association *Fagetum montanum* Rud. s.l. (Isajev, Šijačić-Nikolić, 2003).

The special-purpose object of Scots pine was established in FMU „Jelova Gora" in the spring of 2011 as a result of the study of populational and individual biological and ecological variability of this species in Serbia (Lučić et al., 2011; Lučić et al., 2011a; Lučić et al., 2011b). It was established according to the principle of metapopulation structure in the area of 0.9 ha with 1746 genotypes in total (Lučić, 2011).

In the spring of 2017, clonal plantation of wild cherry was established in the nursery in Požega. The starting material is 42 plus trees, which were selected on several various sites in Serbia based on phenotype characteristics, regularity, abundance, and quality of yield. In the area of 0.5 ha 42 clones with 20 ramets each have been planted (Popović et al., 2019).

In the spring of 2020 clonal plantation of narrow-leafed ash was established in FMU „Progarske Ade, Crni Lug, Drenska Zidine". The starting materials were 45 plus trees from the forest stand within the same forest management unit. The selection of plus trees was performed based on phenotype and production characteristics and health. 45 clones and 637 ramets were planted in the area of 2.55 ha.

Progeny tests

In recent years, several progeny tests have been established in the area of the Great War Island, in which the genetic potential of maternal trees of narrow-leafed ash, black poplar, pedunculate oak, and European white elm is assessed. Progeny trials are mostly established within the framework of scientific research activities in the nursery, less often in the field.

Provenance trials

Several provenance trials have been established in Serbia until present: three provenance tests of Norway spruce (*Picea abies* /L./ Karst.), two of Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) and two of beech (*Fagus* sp.).

The provenance trial of Norway spruce has been established in the vicinity of Ivanjica on 3 sites where 2442 seedlings of Norway spruce have been planted. The seedlings originate from five Serbian provenances: Golija, Zlatar, Cemerno, Radocelo and Kopaonik, as well as three Slovenian provenances: Jelovica, Menina, and Masun (Isajev et al., 1999).

The provenance trial of green Douglas fir has been established in two sites in Serbia, Juhor, and Tanda, where plants produced from the seeds of 29 provenances of Douglas fir practically covering the whole natural range of the species from Oregon to Washington have been planted. The development of provenances has been the subject of ongoing study. (Lavadinović, Koprivica, 1996, 1997).

Two provenance trials of beech were established in the spring of 2007 in National park „Fruška gora" and the Faculty of Forestry Teaching Base „Majdanpečka domena". For establishing these tests two- and three-year-old seedlings of 24 European provenances were used. Within the established trials seedling survival success, height and diameter increment, phenological and physiological characteristics of different provenances are monitored (Stojnić et al., 2010, 2012; Šijačić-Nikolić et al., 2007, 2013).

Clonal archives, living archives and genetic collections

On the sample plot of the Institute of Lowland Forestry and Environment, there are clonal archives of poplar, willow, and black locust. In Lipovica Scientific Research Station of the Institute of Forestry there is a living archive of forest fruit trees. The genetic collection of wild cherry has been established in the area of FE „Sremska Mitrovica" of the PE „Vojvodinašume".

Ex situ conservation of forest trees and shrubs is carried out in:

- Jevremovac Botanical Garden of University of Belgrade - Faculty of Biology, measuring about 5 ha,
- Botanical Garden of University of Kragujevac - Faculty of Science,
- Arboretum of University of Belgrade - Faculty of Forestry, measuring about 3.5 ha.

Organization of ex situ conservation efforts at national level, including main players and stakeholders

Ex situ conservation of forest genetic resources is not treated appropriately on the state level. There is no organized approach to the implementation of *ex situ* conservation plans, which results in a modest volume of established objects. This situation was largely influenced by modest financial resources that were allocated for the above activities in the previous period and certainly by the legislation which is not binding for forest users in terms of the implementation of *ex situ* conservation programme. There is no long-term forest genetic resources *ex* situ conservation programme on the national level and no list of priorities, but the programmes are implemented primarily when technical and financial conditions are met.

Activities towards the *ex situ* conservation are initiated by scientific research institutions, such as the University of Belgrade - Faculty of Forestry; Institute of Forestry, Belgrade; University of Novi Sad - Institute of Lowland Forestry and Environment, with sporadic support of relevant ministries and public enterprises for forest management.

The institutions engaged in the field of *ex situ* FGR conservation do not exchange information, there is often a lack of communication, the problems are not considered similarly and implemented measures are sometimes opposed to one another. Strict procedures for the protection of rare and endangered species, prescribed by the laws, make planning and realization of production of reproductive material for establishment of *ex situ* conservation facilities more difficult in practice.

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

- ✓ Weakness: Insufficient financial resources.
  Priority objectives: To improve the current status of forest genetic resources *ex situ* conservation it is necessary to provide special-purpose financial resources for *ex situ* conservation programme on the national level in the appropriate period.

- ✓ Weakness: Insufficient knowledge and information on the effect of the factors that endanger FGR.
  Priority objectives: To identify the list of priorities of forest woody species for inclusion in intensive *ex* situ conservation programmes in accordance with the degree of threat and prepare a long-term *ex situ* conservation programme; To evaluate the adaptive capacity of priority forest woody species in selected populations; To collect material for conservation in gene banks from old trees which have shown adequate adaptive potential in natural populations of forest trees; To collect reproductive material from the best specimens of trees from endangered populations of forest trees and produce good quality nursery stock for *ex situ* conservation.

- ✓ Weakness: The lack of planning documents for FGR *ex situ* conservation programmes on the national and local level.
  Priority objectives: It is necessary to convert the National program for conservation and sustainable utilization of FGR of the Republic of Serbia for the period 2016-2025 (draft) into a binding document; To develop planning documents for improvement of the status of FGR *ex situ* conservation at the local level.

- ✓ Weakness: Insufficient volume of implemented FGR *ex situ* conservation programmes.
  Priority objectives: Establishing seed orchards of economically significant and endangered species of forest trees; Establishing provenance tests in various ecological conditions; Establishing clonal archives and genetic collections of rare and endangered species; When establishing *ex situ* conservation facilities, the sources of reproductive material should be the facilities in which *in situ* conservation regime has been established.

Priorities for capacity building and research in this area

The capacity building and training of individuals engaged in FGR *ex situ* conservation should be conducted through the following activities:

1. Development of an integrated approach to building and strengthening capacities for *ex situ* conservation of FGR through the building of institutional, social and individual capacities;

2. Development of national program and center for training of public and private sector for *ex situ* conservation of FGR;
3. Development of consulting service for the field of *ex situ* conservation of FGR;
4. Provision of education and training of individuals engaged in the implementation of *ex situ* FGR conservation programme through various courses and workshops (for addressing specific priority issues in this field);
5. Preparation and publication of manuals on the manner of implementation of specific *ex situ* FGR conservation measures, which would be available and friendly for owners and users of forests, forest lands and other forest lands who intend to participate in *ex situ* conservation programs.

In the future, it is necessary to intensify research activities that can contribute to the improvement of the situation in the field of forest genetic resources *ex situ* conservation. For measures and priorities for forest genetic resources *ex situ* conservation to be proposed based on the real status and the degree of threat for species and populations, the activities should be in accordance with the National program of conservation and directed use of forest genetic resources of the Republic of Serbia for the period from 2016 to 2025 (draft).

PART 4

STATE OF USE, DEVELOPMENT AND MANAGEMENT OF FOREST GENETIC RESOURCES

CHAPTER 8. THE STATE OF USE

State of forest genetic resources use in Serbia

The use of forest genetic resources is well defined by legislative, although The Law on reproductive material of forest trees (OG, 2004a) and some rules following that Law need improvements. In practice, we are witnessing the paradox that in the time of increased need for artificial forest reproduction, reforestation, and afforestation, the production of forest reproductive material is declining (in total numbers). There are different guidelines and recommendations for use of FGR in Serbia, and the production of reproductive material which are directly or indirectly included in strategies, laws, and bylaws which regulate this area (Annex 8.1).

One of the most important international documents related to the use of FGR is The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity. Serbia is one of the parties to the Nagoya protocol (from September 2011). The Law on Ratification of the Nagoya Protocol (OG, 2018) is entered into force in 2018.

Certification of forest reproductive material

The Law on forest reproductive material (OG, 2004b) defines four categories:

1. reproductive material of known origin,
2. selected reproductive material,
3. qualified reproductive material and
4. tested (varietal) reproductive material

By §7, reproductive material of known origin can only be used within the same provenance region if there are insufficient reproductive material in the remaining three category or due to fire and natural disasters, while the remaining three categories can be used for raising and restoring forests (OG, 2004a).

The Regulation on the recognition of starting material and control of the production of reproductive material of forest trees (OG, 2005a) prescribes the conditions to be met during the production of the starting material/planting material/seeds of forest tree species, the procedure of its recognition, as well as the manner and procedure of the implementation of the official production control principles (also necessary for certification-related procedures). This document precise content of the application for the recognition of such forest reproductive material

The most of forest reproductive material used in forestry coming from seed stands, categorized as selected reproductive material. There is a total of 179 seed stands registered in Serbia (December 2019) at 2,112 ha (Annex 8.2). Area and number of seed sources for the production of reproductive material of known origin are presented in Annex 8.3.

There are only 3 registered seed orchards in Serbia: 1 of Serbian spruce (*Picea omorika* (Pančić) Purk.) at 2.7 ha and 2 of pedunculate oak (*Quercus robur* L.) in a total area of 16.81 ha, although 7 additional special-purpose objects have been established, for transformation into seed orchards.

The portion of reproductive material from the category of qualified material coming from seed orchards in the total amount of forest reproductive material used is minor. Forest reproductive material of the category of tested material is used for the establishment of poplar and willow plantations. The annual average of reproductive material used in the period 2015-2019 is only 393,000 seedlings.

Trends in production of and demand for forest reproductive material

According to the data from the Forest Directorate (2019), there are 82 registered nurseries for the production of forest reproductive material, registered by 57 producers. Some of those nurseries are registered by private owners, and some of them work within public enterprises (PE), such as PE „Srbijašume" and PE „Vojvodinašume".

The production of planting material in PE „Srbijašume" is carried out in 26 nurseries of which, in 20 nurseries, exclusively or primarily, forest planting material is produced. The total productive area of the nurseries is about 100 ha. All planting material produced in the nurseries of PE „Srbijašume" is subject to regular production control and health checks twice a year, and the seedlings produced in these nurseries are FSC (Forest Stewardship Council) certified (SŠ, 2020). An annual average of 20,000-30,000 kg of various forest tree seeds, depending on crop abundance, is collected for the needs of production of forest planting material, as well as for the artificial regeneration of forest by seeding. The processing of collected wet/dry fruits or cones for seed extraction is carried out in the nurseries or, to a large extent, in the technically and technologically equipped **Center for Processing of Forest Tree Seeds (Forest Seed Center) in Požega**.

The production of forest planting material in PE „Vojvodinašume" is carried out in 18 nurseries, mainly for the PE, and partly for the domestic market. The main part of production relates to rooted cuttings of selected varieties of poplars and willows and seedlings of the remaining part to those of other broad-leaved varieties. Forest seed production is performed in accordance with the Law on forest reproductive material, and seed collecting is performed in registered seed sources, seed stands, or seed orchards. In addition to forest seed production, there is the production of vegetative reproductive material in the form of cuttings, for rooted cuttings production of selected high-yielding varieties (clones) of poplars and willows (VŠ, 2020).

The production of forest reproductive material is way below the needs, considering the strategic and operational management plans accepted. The number of used seedlings (in 000 pcs) for afforestation, reforestation, and plantation establishment in the Republic of Serbia for the period 2013-2018, is presented in table 8.1.

In the period from 2014 to 2023, PE „Srbijašume" plan to: „*conduct afforestation (establishment of new forests) and reforestation on an area of 23,624.7 ha (approximately 2,362 ha per year). In order to carry out this work, it is necessary to produce a total of 49,287,363 seedlings, 19,568,381 of which are broadleaf and 29,718,982 conifer seedlings. The total amount of seed needed for the 2014-2023 period amounts to 305,169.28 kg (approximately 30,516 kg per year), 304,370.35 kg of which is broadleaf seed and 798.93 kg conifer seed*" (Aleksić, Maksimović, 2015). The required quantities of seed should mostly be collected from selected and qualified seed sources (seed stands or seed orchards).

Table 8.1. Number of used seedlings (in 000 pcs) for afforestation, reforestation and plantation establishment in the Republic of Serbia

Year	2013	2014	2015	2016	2017	2018
Total	2194	1154	1736	2822	3171	3202
Broadleaved	1459	700	668	1244	1337	1235
Fagus sylvatica	47	8		5	214	194
Quercus sp.	456	225		148	286	204
Robinia pseudoacacia	260	91			304	291
Other hardwoods	241	147		557	324	358
Populus sp.	373	167		382	158	106
Other softwoods	82	62		121	51	82
Conifers	735	454	668	1578	1834	1967
Picea abies	260	168	386	808	1124	1072
Abies alba	1	3			42	5
Pinus nigra	390	229	216	646	572	758
Pinus sylvestris	76	49	52	88	77	113
Pinus strobus			5			
Pseudotsuga menziesii	1	4	9	33	17	8
Other conifers	7	1			2	11

(Source: SORS, 2020)

In addition to some organizational cracks in public enterprises, as the major producers of forest reproductive material in Serbia, there are some real problems in seed harvesting. The frequency of masting years and years of full seed crop is disturbed and for some species (e.g. beech) there is a lack of seed material. The quality of seed collected in years between the full seed crop is poor and seedling rarely meets the quality standards.

Production and trade of forest reproductive material are regulated by the Law on forest reproductive material (OG, 2004a), and following bylaws: 1) Regulation on the recognition of starting material and control of the production of reproductive material of forest trees (OG, 2005a), 2) Regulation on the quality of reproductive material of poplar and willow (OG, 2009c), 3) Regulation on small quantities of forest seed and forest seedlings (OG, 2009d), and 4) Regulation on balance of forest reproductive material (OG, 2011a).

In last five years there was no import of forest reproductive material and export was symbolic. Only the seed of *Picea omorika*, from seed orchards, was exported. At the operational level, the whole process of seed collecting, seed processing, seedlings production, and seedlings use is monitored by the Forestry Inspection. Reproductive material, in production and trade, need to be followed by appropriate certificates, about basic material and quality.

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

According to the adopted strategies and operational management plans, the needs for the forest reproductive material exceed production by several times.

There are three main challenges for an increase in the production of forest reproduction material. The first one is biological, related to the frequency and quantity of seed crops. The second is organizational, related to the fact that forest reproductive material is producing inside one system for that system (i.e. public enterprise), without the need for developed market and competition. The third one is governmental, related to the lack of determination from the forest authorities for full implementation of the Regulation on balance of forest reproductive material. Implementation of these Regulations would, at any moment, provide true information about the amount, species, and stock types of forest reproductive material in the next five years, according to the adopted strategies and management plans. Opportunities for further improvement of use and production of forest reproductive material are in meeting these challenges in an appropriate way.

There is no strict specialization inside the forestry profession for the production and use of forest reproductive material. This allows the management of forestry companies and enterprises to replace experienced forest engineers responsible for these jobs with new peoples, usually without experience and interest. Although the issues related to forest reproductive material use and production are studied at the University of Belgrade - Faculty of Forestry in series of subjects at the first academic level (Forest Genetics, Tree Breeding, and Forest Reproductive Material and Forest Establishment), and within the specific module of Master academic studies, entitled „*Plant production and conservation of forest genetic resources*", the intense and regular seminars for capacity-building will improve continuous gaining of knowledge, understanding, and performance of forest engineers engaged in use and production of forest reproductive material.

According to Ivetić et al. (2016), beside the choice of the best-suited forest reproductive material (in terms of origin, type, quality, etc.), tracking the identity of the transferred material is necessary, but the application of this theoretical model is often limited at the operational level by the forest reproductive material available on the market. Forest reproductive material producers (including seed collectors, seed processing stations, nurseries) tend to minimize the number of species, due to economic and management reasons which emphasize the need of a project-specific planning period (about five years) to allow the production of appropriate forest reproductive material, from seed source selection based on transfer guidelines to seedling production and planting.

Priorities for capacity building and research in this area

Priorities for research should be given to:

1. the further investigation of genetic diversity to target the conservation and/or utilization goals;
2. investigation of seed collection methods, seed processing, seedling production, and planting methods on genetic diversity of newly established forests;
3. improvement of species selection and provenance to site matching in forest establishment and restoration programs.

CHAPTER 9. THE STATE OF GENETIC IMPROVEMENT AND BREEDING PROGRAMMES

In Serbian forestry, breeding is the basis for the production of reproductive material, the establishment of new forests and plantations, silviculture, and forest management. Forest tree breeding is closely linked to silviculture, so it can be said that the work on tree breeding began at the same time as silviculture. Since then, the results of breeding have been applied from work in the nursery, through the daily selection of the best individuals in the forest and the removal of the phenotypically inferior ones, to the continuous improvement of the reproductive basis and quality in the forests. The goals set were realized by the creation of enriched stands, families of full and half-sibs, new clones, cultivars, and hybrids.

Approaches used for tree improvement and/or breeding

Up to date, different approaches have been taken in tree breeding, depending on the specific species, set goals, and financial resources invested in the specific breeding processes.

Since 1980, as a result of breeding programs, the Institute for Lowland Forestry and Environment (formerly the Institute for Poplars) has registered different willow and poplar varieties (Annex 9.1).

Poplar breeding was performed on: drought stress, disease resistance, growth rate, a predilection for insects, tree properties, and the ability for phytoremediation. Registered willow varieties have better growth and volume increase than the standard variety, are more resistant to plant diseases and harmful insects and adapted to cultivation on different types of soil.

In addition to willows and poplars, breeding activities have been carried out with other tree species, mainly at the level of scientific research or small projects.

Serbian spruce (*Picea omorika* /Panč./Purkyne)

Continuity of breeding can be ascertained for Serbian spruce (*Picea omorika* /Panč./Purkyne) in which multiple selection was applied, from the level of natural populations to the level of seed orchard and controlled hybridization at the level of lineages or different parental genotypes.

The work on breeding of Serbian spruce in Serbia began practically as far back as 1865 when Josif Pančić stated: „*that Serbian spruce and fir are not the same things, moreover that Serbian spruce is much more akin to spruce than to fir*". From that moment, the analysis of the variability of the Serbian spruce in its natural populations begins, intending to get to know the genetic variability and potential of this species more closely and more widely.

Selection of trees, based on phenotypic characteristics, was carried out based on research in natural populations of Serbian spruce populations, which served to establish an experimental clonal seed plantation on Jelova Gora (1963), which soon showed its many shortcomings.

Further work on Serbian spruce breeding was carried out in the direction of the establishment of cultures of planting material originating from natural seed stands. These cultures very quickly become the next stage in breeding, with the phenotypically best, after mass selection, being 3 cultures: Bela Zemlja, Popova Luka, and Šargan (Tucović, Isajev, 1983; Isajev, 1987). Serbian spruce population surveys were conducted in isolated cultures. Individual selection, based on phenotypic characteristics, selected 100 test trees, which were analyzed for: phenology of flowering, abundance and frequency of micro- and megastrobili formation, quality and quantity of seed crop, the influence of photoperiodism on the length of the vegetation period. Further selection selected 50 test trees, from which seeds were collected to obtain seedlings of different half-sibs, from which in 1987 a generative seed orchard was established in the village Godovik, Požega municipality (Tucović, Isajev, 1988). Based on the results of investigations of variability between and within embedded half-sib lines and obtained data on the dynamics of tree growth and development; regularity and abundance of flowering and seed crop, and morphological characteristics of germinants, selection of superior lines, that is, genotypes within the lines was performed. According to the model of incomplete diallel crossing, controlled hybridization was performed, which included 21 combinations at the line level, ie 48 combinations between different parental genotypes. By analyzing the morphometric properties of the cones of the parent individuals and their hybrid combinations, combinations were recorded which showed a heterosis effect for all or only some of the analyzed characteristics of the cones. Based on salts soluble seed proteins, similarity coefficients were calculated, that is, the genetic structure of each hybrid combination was analyzed. 12 hybrid combinations were selected, which are characterized by high mean values of the analyzed morphometric properties of the cones, with some of them showing a heterosis effect for one, two, or all three analyzed properties. An analysis of the parental individuals participating in these hybrid combinations selected the genotypes that show the best combining ability as individuals selected for mothers or fathers. A model was created for raising an experimental clonal seed plantation for the production of Serbian spruce hybrids (Šijačić-Nikolić, 2000).

Sycamore - *Acer pseudoplatanus* 'Atropurpureum'

Continuous monitoring of phenotypic expression of leaf of 9 lines of the *Acer pseudoplatanus* 'Atropurpureum' half-sib lines developed in the juvenile stage was conducted to assess the genetic potential of native trees whose primary selection criterion was red reverse of leaf. Based on the literature data, that the seed sowed results with 50% of individuals with red and 50% of individuals with green leaves, the conducted research aimed to select native trees whose offspring will have as much red leaf as possible. Bearing in mind that experimental studies to date show that the inheritance of leaf color character is mainly done through the mother, which is designated as matocrylic inheritance, thus creating a good starting point for the production of seedlings of this cultivar by generative means. The results of the research carried out over five years showed the differentiation of maternal trees into those whose offspring had a more red or green reverse of leaves, respectively. Bearing in mind that the expression of the red leaf reverse is continuous on lines 5, 8 and 3, while the expression of the green leaf reverse is a characteristic of lines 9, 2, 7 and 4, during all 5 years (Šijačić-Nikolić, Milovanović, 2006; Šijačić-Nikolić et al., 2009a), one can talk about the genetic determination of the color of the reverse of the leaves of mother trees that can be used as a seed source for the mass production of seedlings of this cultivar by generative propagation (Šijačić-Nikolić et al., 2011).

Lime (*Tilia* spp)

Evaluation of the potential of different lime (*Tilia spp*) genotypes for phytoextraction of heavy metals (Pb, Mn, Zn, Ni, Fe) was performed at the level of 12 genotypes analyzed from the area of Fruška Gora NP selected along the M21 highway.

The results obtained showed that the content of heavy metals in lime leaves was far below the average values in all genotypes except genotype 7 for lead and genotype 7 and 8 for iron. The results of the analysis of variance components showed that of the four components (locality, genotype, locality x genotype and error) the interaction between locality and genotype is the only one that does not contribute to variance. The content of Pb, Mn, Fe and Zn in the leaves is primarily influenced by the genotype, while the Ni content in the leaves can be considered as a consequence of the locality. Selection of genotypes capable of absorbing higher amounts of heavy metals than others can serve as a good basis for phytoextraction as a technology to remove heavy metals, metalloids and radionuclides from the environment by using suitable plant species and genotypes capable of adopting and accumulating pollutants in portions plant tissue (Šijačić-Nikolić et al., 2012a).

Bald cypress (*Taxodium distichum* (L.) Rich.)

Taxodium is an introduced species in Serbia in wetlands and floodplain habitats. The potential of this species as a basis for the purposeful production of planting material was investigated at the level of the seed stand located in the vicinity of Bačka Palanka. The research conducted included analyzes at the seed stand level, 20 test trees, progeny tests, and a pilot facility established close to the existing seed stand.

The results obtained indicate a high gene-ecological potential of the bald cypress at the level of the seed stand, as well as the expressed variability of the analyzed properties between test trees and half-sibs in the progeny test and the established pilot facility. Seed crop analysis indicates a satisfactory quantity and quality of crop at the seed stand level, which is a good starting point for improving the mass production of seeds of this species in Serbia. Initiated research is continuing with the aim of selecting superior lines or genotypes as a basis for the mass production of bald cypres reproductive material in Serbia, which opens the possibility of wider application of this species for afforestation of wetlands and floodplain habitats (Popović, 2013).

European hop-hornbeam (*Ostrya carpinifolia* Scop.)

European hop-hornbeam is a very significant species of pioneering communities of protective character. There are no registered European hop-hornbeam seed facilities in Serbia, as well as organized production of reproductive material. To get acquainted with the genetic potential of the species and to properly select adequate reproductive material for mass afforestation, the variability of the European hop-hornbeam at the level of the half-sib lines from part of its range was evaluated. Investigations were carried out in three localities: Jagnjenica, Junaci, and Vojmisliće; northeast of Lake Gazivoda, the Crni Vrh – Deževski, with 15 seed trees selected at each site. A total of 945 seedlings were analyzed from 45 half-sib lines.

On two-year-old European hop-hornbeam seedlings, the variability of the studied quality indicators between the half-sib lines was noted. Seed trees with the highest potential for the production of reproductive material were clearly distinguished in this regard. In the conducted research, as the mother tree with the highest quality offspring can be distinguished tree 15 from provenance Junaci. There is also variability in the studied quality indicators between provenances, except for height after the second year and the total mass of dry seedlings. Due to the highest values of root-collar diameter in the first and second years, as well as the dry mass of seedlings, the provenance of Jagnjenica can be distinguished, especially for the predominant use of European hop-hornbeam seedlings for planting in difficult terrain. The influence of half-sibs and provenance on the concentration of nutrients studied should be further investigated on a larger number of samples. In this regard, the fact that the highest concentrations of potassium in the shoot and the root have seedlings from the provenance of the Jagnjenica, which also show the highest values of diameter, is encouraging, which is a reliable indicator of root development (Ivetić et al., 2015).

Beech (*Fagus* sp.)

In order to improve the mass production of leaf-ornamental beech cultivars in Serbia, the research was performed including 10 trees: three leaf-ornamental beech cultivars (*Fagus sylvatica* 'Purpurea', *Fagus sylvatica* 'Tricolor', and *Fagus sylvatica* 'Purpurea Tricolor') and one beech tree from the Belgrade area. These trees were used as grafting scions sources. Beech seedlings of different ages from natural offspring and produced in the nursery originating from four populations in Serbia were used as rootstocks for grafting.

The grafting was performed in the nursery of the Faculty of Forestry in Belgrade, where experimental fields were established in 2011 and 2013. Two methods of copulation were applied - splice grafting and wedge grafting. The variability of maternal trees was assessed using morphological, anatomical, physiological, phenological, and molecular markers, and the variability of the beech rootstocks was estimated based on genetic characterization using microsatellite markers. Both quantitative (height, root collar diameter, and number of leaves) and qualitative (color of leaves) characteristics of produced grafts were analyzed.

Based on the obtained results, it can be concluded that there are leaf-ornamental beech cultivars on the territory of Belgrade that can be used as a starting material for the improvement of mass production of ornamental plants. The conducted research confirms the importance of the appropriate choice of methods and timing for grafting. Research performed at the level of molecular markers indicated that the genetic similarity of grafting components is an essential precondition for the success of heterovegetative propagation, as was confirmed by the results of practical grafting (Nonić, 2016).

Narrow-leafed ash (*Fraxinus angustifolia* Vahl.)

Within the project „Production of improved reproductive material of narrow-leafed ash (*Fraxinus angustifolia* Vahl.) in the Great War Island", work has been started on the breeding of this species aiming at producing planting material for its reintroduction to the Great War Island.

In the Great War Island, narrow-leafed ash is a species that used to occur in nature in the type of white willow forest (*Salicetum albae*) on recent, moist and layered alluvial deposits and in the type of white and black poplar forest (*Populetum albo- nigrae* Slav 52) on a mosaic of different alluvial soils, and today it is almost nonexistent. Therefore, the production of planting material of narrow-leafed ash is based on native trees selected in the area of the Special Nature Reserve „Gornje Podunavlje", within the boundaries of Karapandža and Monoštorske Forests, because of their ecological characteristics close to the Great War Island, and a significant gene pool of this species. Tree selection was performed based on phenotypic characteristics and abundance of seed crop.

Assessment of the genetic potential of the selected trees started at the level of 20 half-sibs, in a progeny test established in a nursery at the Faculty of Forestry, and continues at a pilot facility established in the fall of 2018 in the Great War Island area.

Black poplar (*Populus nigra* L.)

Within the project „Production of improved black poplar (*Populus nigra* L.) reproductive material on the Great War Island", work on breeding of this species continued with the purpose of producing reproductive material for reforestation on the Great War Island.

The production of improved black poplar reproductive material is based on years of research into a gene pool of this species in the Great War Island. A total of 907 trees were recorded by field reconnaissance, which represents the gene pool of the starting population. Within this population, 15 native trees were selected. The selection of native trees was done according to conservation principles.

The field gene bank was established in the fall of 2015 on the principle of metapopulation structure, which ensures genetic diversity, greater stability and better adaptability to environmental conditions. 802 seedlings were planted in the field gene bank on an area of 0.80 ha. It consists of two blocks that have an equal number of seedlings. Each block contains all 9 clones, which are represented by 25 seedlings, a total of 50 seedlings of each clone (Maksimović, 2015).

From the cuttings collected from an established gene bank, a clonal test of offspring in a nursery at the Faculty of Forestry was established in the spring of 2017. As part of this test, the survival of cuttings (seedlings), height, and diameter at the end of the first growing season was analyzed. Differentiation between clones was observed and continued to be monitored at the pilot facility established in the fall of 2018. Work on the production of improved black poplar planting material will continue at the level of superior genotypes.

Pedunculate oak (*Quercus robur* L.)

The activities on the breeding of pedunculate oak are related to the project „Production of improved reproductive material of pedunculate oak (*Quercus robur* L.) in the Great War Island". In the area of the Great War Island, pedunculate oak is a species that once arose from nature and has now disappeared almost completely. The inability to select native trees in this area necessitated the selection of outbound populations.

The first starting population was selected from the registered seed sources in the Forest administration „Morović", Forest estate „Sremska Mitrovica" (the provenance of S. Mitrovica), which are ecologically belonging to the wetter variant of pedunculate oak-hornbeam forests in the non-flooded area and represent the largest complex of this species in Serbia. Gene pool testing of this population began in the fall of 2014, collecting acorns from 40 selected native trees: 20 from the „early" phenoform and 20 from the „late" peduncle oak phenoform. The available gene pool was tested in a progeny test established the same year at the Faculty of Forestry nursery and pilot facility, which was established from two-year-old seedlings of 12 half-sibs, on the Great War Island in the fall of 2016. An analysis of the survival and development of five-year-old seedlings of this provenance in a pilot facility in the Great War Island, in the fall of 2019, shows satisfactory results, suggesting the introduction of seedlings of this population into the Great War Island.

The second starting population was selected within the registered seed sources in the area of the special nature reserve „Gornje Podunavlje", ie. from Forest estate „Sombor" (provenance Sombor). Special nature reserve „Gornje Podunavlje" is a protected natural asset of the first category, which extends along the left bank of the Danube River (from 1,367 to 1,433 km of the total flow). It is part of a large complex that extends through two neighboring countries (Hungary and Croatia) and, overall, is one of the last major floodplains on the European continent.

Assessment of the gene-ecological potential of selected provenances: Sremska Mitrovica and Sombor, was performed in a progeny test established in the nursery of the Faculty of Forestry, University of Belgrade, in autumn 2017, at one- and two-year-old seedlings. The analysis of the gene-ecological potential of selected provenances continues at a pilot facility established in the fall of 2019 in the Great War Island, intending to select adequate provenance for the mass production of seedlings for the reintroduction of pedunculate oak to the area.

European white elm (*Ulmus laevis* Pall.)

Activities on breeding European white elm (*Ulmus laevis* Pall.) aimed at targeted production of planting material. The population of European white elm located on the Great War Island and representing the remains of former natural populations that need to be restored was selected as the starting population. The selection of mother trees was performed based on phenotypic characteristics of trees and the quantity and quality of seed crop, which was monitored for several years. Assessment of the genetic potential of maternal trees began at the level of the offspring test and continued in field trials established in the area of the Great War Island. Activities in the direction of targeted production of planting material continue through the project „Production of improved reproductive material of European white elm (*Ulmus laevis* Pall.) on the Great War Island". The analysis of the content of heavy metals: zinc, lead, nickel, manganese, and iron in the leaves of test trees was performed and the strong influence of genotype on the accumulation of all heavy metals was determined (Devetaković et al., 2015; Devetaković, 2017).
Based on the results of previous research, genotypes that have good quantity and quality of seed crop and which are already used for mass production of seedlings of this species for afforestation on the Great War Island have been selected.

Prioritization of uses and traits in tree improvement and/or breeding -

Depending on the tree species, breeding activities took place in the direction of improving different properties (Annex 9.2). When it comes to poplars, breeding was performed on: drought stress, disease resistance, growth rate, predilection on insects, wood properties, and ability to phytoremediation. Registered varieties have better growth and are more resistant to plant diseases and harmful insects and are suitable for growing on different types of soil. For other species that were the subject of breeding, the goals were as follows: a selection of mother trees with good quantity and quality of seed crops as a basis for targeted production of planting material, selection of genotypes capable of phytoremediation of heavy metals and improvement of ornamental cultivars.

Organization of tree improvement and/or breeding programmes

Organized breeding programs in Serbia in recent years have been implemented at the Institute of Lowland Forestry and Environment in Novi Sad, whose breeders have created a large number of clones of poplars and willows that are recognized as starting material for the production of tested (varietal) reproductive material of forest trees, according to applicable laws.

Other activities on breeding different forest tree species took place within the scientific research work that was realized at the University of Belgrade - Faculty of Forestry and the Institute of Forestry in Belgrade.

Use of current and emerging technologies in tree improvement and/or breeding

Mass selection is the most frequently used breeding method in Serbia. As a result of mass selection, the best stands, populations, or groups of individuals were selected to improve the production of quality reproductive material. In addition to mass, individual selection is applied, where within the starting populations, based on phenotypic characteristics, selection of mother (test) trees whose assessment of genetic potential is performed at the level of progeny tests established in the nursery or field trials. The use of hybridization as a breeding method has been used much less frequently, primarily due to limited financial resources.

Needs, challenges and opportunities for tree improvement and/or breeding

✓ Weakness: Lack of understanding the importance of forest tree breeding in the forestry profession.
Priority objectives: To understand the importance of plant breeding in the modern forestry profession and apply it more intensively, for forestry experts, the goal is to return the subject Plant Breeding to the compulsory subjects, which is currently studied as an elective subject in the second year of the Department of Forestry at the Faculty of Forestry, University of Belgrade. The same applies to the subject Breeding of ornamental plants, which is taught at the Department of Landscape Architecture.
Currently, with the status of an elective subject, many future forestry experts do not acquire knowledge in plant breeding or apply it later in practice, and when they find themselves in management positions, they do not recognize the importance of breeding activities or not support them.

✓ Weakness: Lack of project activities related to forest tree breeding.
Priority objectives: The competent ministries, as well as other financiers, should be pointed out the importance and possibilities of forest tree breeding, to define breeding programs and provide financial resources for their implementation in a longer time. So far, forest tree breeding activities have been financed sporadically, mainly on the level of one-year projects and with insufficient financial resources for more serious research and application of modern breeding methods.

✓ Weakness: Lack of inter-institutional cooperation on tree breeding.
Priority objectives: In Serbia, there are three institutions that more or less deal with the improvement of forest trees, each of which independently chooses the species, goals and methodology. The priority goal is the transparency of breeding activities, which should lead to mutual cooperation between breeders of different institutions to exchange acquired knowledge and joint activities.

✓ Weakness: Undefined breeder's intellectual property rights for new varieties.
Priority objectives: Establish and respect the right known as „Plant Breeder's Right" which is applied in Europe. When breeders receive Plant Breeder's Right for certain varieties and a certain area, they can charge a fee from the sale of the material used. Therefore, it is necessary to establish such an institution in Serbia, which would be in charge of the valorization of breeding work.

✓ Weakness: Impoverishment of genetic diversity.
Priority objectives: Genetic diversity is the basis for breeding processes. We are witnessing the loss of genetic diversity, which significantly narrows the basis for breeding. Therefore, the priority goal is the protection and targeted use of the available gene pool, especially those tree species that are rare, endangered, at risk or economically important.

Priorities for capacity building and research in this area

Capacity building and research in woody plant breeding include the following priorities:

1. Providing adequate education of future forestry experts in the field of breeding, at all levels of study at the University of Belgrade - Faculty of Forestry.
2. Defining breeding programs, depending on the needs and priorities set for the forestry profession.
3. Defining a national program in the field of forest tree breeding.
4. Ensuring continuous financing of breeding programs by the state or interested parties.
5. Providing modern laboratories and equipment for the implementation of breeding programs.
6. Establishment of inter-institutional cooperation at the level of breeding programs.
7. Intensification of international cooperation and continuous education of our experts in the field of forest tree breeding.
8. Promotion and implementation of the obtained results of breeding programs.

CHAPTER 10. MANAGEMENT OF FOREST GENETIC RESOURCES

The current Law on forests of the Republic of Serbia (OG, 2010) pays special attention to protected species of forest trees. It prohibits the felling of trees, the destruction of young trees, and the collection of seeds of strictly protected species of forest trees, determined by special regulations on nature protection, unless they are a source of disease and pest infestation, or if they endanger humans and objects.

For the conservation and direct use of the gene pool of these species, forest management plans contain measures for the protection, use, and extension of their range.

In the part related to the production of forest reproductive material, the Law on Forests defines the management of seed objects as follows: "*Seed objects, except seed sources for the production of seeds of known origin, are managed in a way that ensures maximum production of quality forest seed and enables easier harvesting, ie seed collection*".

Based on the foregoing, it can be concluded that protected forest species, reproductive material, seed management, and forest genetic resources are taken in different contexts into account in the Serbian forestry planning documents, but the way of their management is not defined, which is the case in many other European countries.

Forest genetic resource management, for the time being, can only be considered within the forest management planning system. The management plans, which are adopted for 10 years, contain the state of the protected parts of nature, which includes the listing of plant species having the character of natural rarities, in accordance with the Rulebook on declaration and protection of strictly protected and protected wild species of plants, animals and fungi (OG, 2010c), which can be considered as the basis for the management of FGR of relict, endemic, rare and endangered species of forest trees and shrubs.

The latest forest inventory of the Republic of Serbia (2020) will provide the possibility of controlling the number and analysis of the spatial distribution of trees from the above categories for conservation and direct use of the available gene pool.

Management of forest genetic resources in natural and planted forests, and in other wooded lands

Management of naturally regenerated coppice stands: Coppice forests are naturally regenerated by clear and selective felling. In both cases, coppice forests are managed on the principle of sustainability. This method of restoration is justified in even-aged stands, when the felling of all trees is done simultaneously. When applying this method of regeneration to a non-even-aged (selective) stands, the growth of shoots depends to a large extent on the light conditions, which must be regulated with the silviculture measures.

From a genetic point of view, this management system cannot be classified as good or bad. It reflects on genetic resources based on the genetic value of the previous stand, which was clear-cut. Compared to high forests, coppice forests are genetically poorer, resulting in smaller trees of lower quality.

Management systems with high naturally regenerated stands

In the case of natural regeneration of high forest stands, hereditary traits are passed on to the next generations by seed. Regeneration is performed by removing the trees from the stand at a certain age with various silviculture cuts. Depending on the method of removal of the trees of the mature stand and the method of establishing a new forest, all the fellings of natural regeneration are divided into three basic methods: clear-cutting, shelterwood cutting, and selective cutting. At the end of the natural rejuvenation process, groups of trees of the same or different ages, within naturally regenerated stands, can be the result of different ancestral influences, then selection effects, as well as the impact of thinning implemented.

In all plans, as a result of the trade-off between the ecological and economic component, that is, conditioned by site rating, bio-ecological characteristics of species and forest management objectives in the multifunctional approach, appropriate management systems are established, which are equally applied (shelterwood cutting, selective cutting, group selection cutting) (Medarević et al., 2014). Clear-cutting is not permitted in the Republic of Serbia (except for intensive poplar plantations, black locust stands, coppice, and degraded forests).

Forest Regeneration System - Shelterwood or gradual cutting: With this system, natural regeneration begins by gradually removing some trees in the stand, increasing the amount of sunlight reaching the tree canopy, as well as the heat reaching the soil. Performing the proper shelterwood cutting promotes abundant fruiting and germination of seeds, but reduces the number of trees involved in natural regeneration, thus reducing genetic diversity in future stands. Besides, the relatively short rejuvenation period (5 - 20 years) contributes to the fact that genetic information is not fully transmitted to subsequent generations.

Forest Regeneration system – Selective cutting: With this system natural regeneration is a continuous process, with the old stand not completely removed. Unlike shelterwood cutting, in which the renewal takes a relatively short time, in selective cutting system seeds from all crop years are used for regeneration. Removing (selecting) trees creates a space that allows the normal growth and development of the undergrowth that was in the shade. At the same time, conditions are created for the emergence of new seedlings. The rest of the stand includes trees that remained in the stand, as well as physiologically mature trees that were in the stand before performing the cutting, which participated in the formation of the seedlings, which was in the shade. This mode of regeneration simulates the succession dynamics in natural stands, and because of the permanent natural regeneration process involving a large number of physiologically mature trees, it is a very suitable way of managing genetic diversity regarding conservation.

Forest Regeneration system – Irregular group shelterwood system (Gauer Bavarian femelschlag): In this system, the regeneration on some parts of the stand is realized at different times, which results in the creation of more age groups. Although tree selection by the group is not limited in time, it is common for the entire stand to regenerate after 30-40 years. The consistent application of this management system has a particular impact on the biological stability of restored stands. As the system is very flexible, it must take into account the dynamics of the development of managed forest trees species.

Forest Management System - Close to Nature Forest Management: The principle of forest management in a natural way is the highest possible use of natural processes and mechanisms of self-regulation of forest ecosystems to meet forest operational objectives. To the extent necessary, active control of such processes is practiced, so that the focus is on the high quality and vitality of future stands. In this management system, different aspects of several forest management modes are combined to produce environmentally stable forests. It provides several benefits - sustainable management, adequate timber production, ecosystem stability, economic profit, biological diversity, the fulfillment of the social component. The concept with native species, as well as natural regeneration with the presence of different age classes, are some of the positive elements of this management model, which play a major role in biodiversity conservation.

While, in theory, young stands can provide an adequate genetic basis comparable to that found in forests with an appropriate management system, in practice this type of data does not exist. Certain management regimes change population density, pollen, and seed dispersal rates, but these effects are overestimated because populations of different densities do not cause significant differences in pollen dispersal. It is unknown whether the best arrangement of age-appropriate tree classes, as well as the amount of reproductive-capable fructification organs, can be maintained in forests created by natural regeneration.

Up-to-date management and establishment of new forests artificially

The artificial establishment of new forests in Serbia especially took place during the 1970s and 1980s, so that today there is 174.800 ha of artificially raised stands and plantations in Serbia, which is 7.8% of the total area under forest. Of these, 135,600 ha are state-owned, while 39,200 ha are privately owned. So far, the management of these forests in Serbia has been poorly planned, so it is mostly non-cultivated stands with a large number of trees per unit area. Afforestation in recent decades has been largely done by conifers in inappropriate habitat (Isajev et al., 2004). As a consequence of the wrong choice of species in relation to habitat type, as well as climate change in the last ten years, there have been mass occurrences of drying of artificially raised conifers (Aleksić et al., 2013).

Bearing in mind the specifics of the management of artificial stands so far, special emphasis should be placed on the selection of starting material (seed stands and seed orchards), the method of collecting seeds, as well as on storage, processing (sorting) and growing conditions of forest reproductive material when establishing new forests. In this way, a high level of genetic diversity of artificially raised stands can be ensured, which is crucial for adapting to future environmental changes.

From a genetic point of view, artificial regeneration reflects on the genetic resources of a newly established forest based on the genetic value of the forest reproductive material used to establish it, as well as on the methods of the establishment (by sowing seeds or planting seedlings).

Forest management of varying degrees is involved in the conservation of FGR. While management can be assumed to have the most significant impact on natural forest genetic resources, it cannot be said with certainty. The occurrence of certain threatening factors, whether natural or anthropogenic, is reflected in the regeneration process. Management systems generally simulate natural processes when it comes to regeneration.

The management concept that relies on natural regeneration is based on genetic diversity that is passed on to future generations, especially in the case of longer-term regeneration cycles, as well as species of different ages.

Due to the large areas covering forests of vegetative origin, the importance of the conservation of less quality, coppice forests has recently been recognized.

Consequences of the changes in the forest sector for forest genetic resources and their management

Forest management enhances natural regeneration, which ensures genetic diversity and protection of all common forest functions. The system has been thoroughly elaborated and incorporated into all strategic and operational planning documents in forestry.

The ownership structure of forests in Serbia is an aggravating circumstance when managing forest genetic resources, since 47% of the area under forest is privately owned, which makes it difficult to implement management plans, which causes the problem of sustainable management of these forests. On the other hand, state-owned forests make up 53% of the total area under forest and are suitable for the implementation of the plans, since they are used by public forest management companies, which have a clear vertical hierarchical structure that allows consistent implementation and implementation of forest management plans.

Also, public companies are committed to responsibly managing forest resources, by improving working methods and developing management responsibilities, as evidenced by FSC forest management certificates, owned by both PE „Srbijašume" and PE „Vojvodinašume". The certificates obtained are confirmation that forests and forest lands are managed in an environmentally friendly, socially, and economically viable manner, which is of great importance from the aspect of conservation of FGR.

Although forests in Serbia are managed following the principles of sustainable forest management, the increasing frequency of natural disasters (floods and ice), with unprecedented economic and environmental consequences for Serbian forests, indicate the need to improve the planning system from the aspect of risk management, as well as to strengthen the stability of forestry. And thus creating resilience to extreme weather, to achieve the global goal of sustainable forest management.

Therefore, taking into account the dynamics and extent of the threat to forest ecosystems, it is necessary to adapt and change forest management planning procedures by introducing a new approach to forest management planning, which is based on the concept of close to nature management. This planning concept is aimed at increasing the structural, specific, and any other diversity of forest ecosystems, as a condition of their stability and resilience.

The development of a new approach to forest management planning, which has not yet been fully recognized in Serbia, should give even greater importance to the protective functions of forests, and thus to the conservation of FGR.

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

Prerequisites for drafting quality planning documents for FGR management are:

1. A precise cross-section of the state of FGR in forest ecosystems obtained through national inventory, stand inventory and special studies;
2. Strategic and legal frameworks that emphasize the need to achieve the goal of conserving FGR in forest management;
3. Integration of goals and measures defined by the National program for conservation and sustainable utilization of FGR of the Republic of Serbia for the period 2016-2025 (draft) into forest management planning processes.

Only when data obtained through a forest inventory and stand inventory are credible to the state of FGR in the field, measures can be properly planned to conserve and improve them. With the development of awareness of the importance of maintaining the gene pool of rare and threatened species, efforts are being strengthened to develop field data collection and processing methods to lay the best possible basis for obtaining planning documents.

The planning documents related to the management of FGR should meet the following criteria:

1. Enabling the highest level of use of natural processes and mechanisms of self-regulation of forest ecosystems to preserve biodiversity.
2. Selection of the most favorable method of regeneration, which in the best way simulates certain natural processes, and thus the genetic processes that occur in a particular constituent, with particular emphasis on a longer regeneration period.
3. Selection of those structural forms (even-aged, multi-aged) that best ensure the conservation of biodiversity of forest ecosystems under given site conditions.
4. Improvement of the planning system from the aspect of risk management, as well as the strengthening of the stability of the forest fund and the creation of resilience to extreme weather conditions for sustainable forest management.
5. Forcing mix of species and, to the greatest extent possible, age diversity.
6. Harmonization of logging with the conservation of forest genetic resources and clearly defining the procedure for selecting logging trees.
7. Carrying out the regeneration cuttings at the intensity that creates the most favorable conditions for the development of the existing and the emergence of new offsprings.
8. Preserving bioecological stability in forest ecosystems to ensure natural rejuvenation.

Planning documents relating to the establishment and management of artificially established stands should also meet the following additional criteria:

1. Choosing the best method for establishing new forests (by sowing seeds or planting seedlings).
2. Targeted production of seedlings in relation to type of planted forest and site conditions.
3. Selection of native species of trees for afforestation, with particular emphasis on the concept of climate-smart forestry.

4. Use of seeds of high genetic value and high genetic diversity within species and seed lot (by collecting seeds from a large number of individuals within seed stands and seed orchards).
5. Transfer of forest reproductive material within the same ecological-vegetation areas, ie defined regions of provenance.
6. Maintenance of newly established forests by applying appropriate care and protection measures, favoring species significant from the conservation and enhancement of forest genetic resources.

Priorities for capacity building and research in this area

Based on the criteria for the improvement of the planning documents, the weaknesses of forest owners and users can be clearly defined to improve the forest management system. The analysis of the criteria for the development of the forest management plans indicates that capacity building of forest owners and users is necessary as follows:

1. Improve the current methodology for collecting information on the state of forest genetic resources through regular inventory and, where appropriate, thematic studies.
2. Develop a methodology for incorporating genetic diversity data obtained into the process of planning and management of forest ecosystems.
3. Develop a training program for all forest owners and users to integrate the principles of forest genetic resource conservation into regular management systems.

Forestry practice has shown that the quality of planning documents is as important as the degree of implementation. The un-realization of the planned activities, as well as their partial realization, represents a serious shortcoming. Therefore, it is imperative to develop, as simply as possible, a way of monitoring the implementation of the planned activities, as well as the state of FGR from the aspect of the reaction to the proposed measures, using modern scientific methods.

PART 5

STATE OF CAPACITIES AND POLICIES

CHAPTER 11. INSTITUTIONAL FRAMEWORK FOR THE CONSERVATION, USE, AND DEVELOPMENT OF FOREST GENETIC RESOURCES

This chapter presents an overview of the institutional and regulatory framework for the conservation of forest genetic resources in Serbia, while detailed analyzes of these topics are presented in previous research (Nonić et al., 2017a, 2017b, 2019a; Nonić D. et al, 2019).

National coordination mechanisms and institutions dealing with forest genetic resources

Various institutions and organizations are dealing with forest genetic resources conservation in Serbia. In most cases, the competencies of institutions and organizations are not exclusively related to the FGR conservation, but also include other activities. Conservation of FGR is a primary objective within the competence of public administration in forestry and nature conservation (competent ministries); public service in nature conservation; public enterprises in forestry and nature conservation; educational and research organizations.

Overview of the institutions and organizations dealing with forest genetic resources

The top institutions of public administration are the Ministry of Agriculture, Forestry and Water Management (through the work of the Forest Directorate), and the Ministry of Environmental Protection (through the work of the Sector for Nature Protection and Climate Change). The public service for nature conservation is responsible for the support and control in the performance of professional activities. The public enterprises for forest management and public enterprises for the management of national parks (NP) as well as other organizations, including non-governmental organizations (NGOs), are responsible for the implementation of professional activities on FGR conservation.

The **Ministry of agriculture, forestry and water management**, through the work of the ***Directorate of Forests***, is responsible for the formulation and implementation of the state forestry policy and relevant legislation at the national level. The *Forest Directorate*, as an administrative body within the Ministry, was established to carry out tasks related to forest and forest conservation policy; promotion and use of forests and wildlife; implementation of measures for the protection of forests and wildlife; control of seeds and planting material in forestry, etc. (DOF, 2016). When it comes to tasks related to the conservation of the FGR, the Forest Directorate issues the strategic frameworks and regulations that the forest users (PE for state forest management, PE NP, etc.) are obliged to implement (e.g. Law on reproductive material of forest trees, Law on forests, with accompanying regulations) and controls the implementation of laws, finances projects involving faculties, institutes, public companies, it keeps registers of stool beds, forest nurseries and seed sources (Lalović, 2016).

Within the **Ministry of environmental protection**, the ***Sector for nature conservation and climate change*** carries out state administration affairs, which relate to: protection and improvement of the environment; inspection in the field of environmental protection; nature conservation; approving cross-border traffic of protected plant and animal species, etc. (MEP, 2020). This Sector participates directly in the process of FGR conservation by preparing regulations and controls its implementation (e.g. Law on environmental

protection, Law on nature conservation, Law on national parks), approving management plans for certain protected areas (for NPs the approval is given by the Government of Republic of Serbia) (Lalović, 2016). The ***Environmental Protection Agency*** manages the environment information system, including nature protection indicators at the national level.

The **Institute for nature conservation of Serbia**, Belgrade, is a public professional service responsible for the protection and promotion of natural heritage in Serbia. It works on biodiversity conservation, proposes the designation of protected areas, develops protection studies, which determine the values of the areas proposed for protection and the way management of these areas, issues decisions on the conditions of nature conservation in the process of drafting project documentation, spatial and urban plans, strategies, etc. in all activities that affect nature (INC, 2017). The Institute for nature conservation of Serbia manages the Central register of protected natural areas of Serbia and cooperates in the exchange of data with other government institutions that collect data on the environment at the national level (i.e. the Republic Geodetic Authority, Statistical Office of the Republic of Serbia, and Environmental Protection Agency) (Vasilijević, et al. 2019).

The **Institute for Nature Conservation of Vojvodina Province**, Novi Sad, works on the territory of Autonomous Province (AP) Vojvodina. The activities of the Institute related to the nature conservation, refers, among others, to expert supervision on the protected natural resources with the proposal of measures; monitoring the conditions and estimated level of nature conservation and the degree of vulnerability of wild species and their habitats, types of habitats, ecosystems, ecologically significant areas, protected areas, ecological corridors, ecological networks, and regions, etc. (INCVP, 2020).

The **Provincial Secretariat for agriculture, water management and forestry** participates in drafting and proposing legislation, approving special management plans and management programs for private forests, prepares general guidelines for the development and improvement of forests, etc. (SAWF, 2020).

The **Provincial Secretariat for urban planning and environmental protection**, among other issues, declares a state of environmental endangerment and controls the exploitation and protection of natural resources, in the territory of AP Vojvodina, provides continuous control and monitoring of the state of the environments, gives conditions for securing the measures for the environment protection, etc. (SUPEP, 2020).

PE for state forest management „Srbijašume", Belgrade, is a manager of numerous protected areas. It participates in the improvement of the state of FGR through the management measures, provides information from the field on the state and current problems, and participates in the preparation of regulations, the allocation of seed sources and the production of planting material in the forest nurseries, etc. The work of two divisions is of special importance for the conservation of the FGR. The ***Division for genepool, seed science and nursery production*** is directly engaged in the FGR conservation by defining the business policy of PE „Srbijašume" within the scope of activity of gene pool, seed science, and nursery production, creating guidelines and monitoring the preparation and implementation of the Plan of production of reproductive material of forest and horticultural species trees at the level of PE „Srbijašume". The

Division for forest protection and protected areas is in charge of coordinating the management of protected areas and activities on protection against diseases, harmful insects, rodents, fire, illegal logging, etc.

PE for forest management „Vojvodinašume”, Petrovaradin (Novi Sad), is a manager of 17 protected areas (VŠ, 2020). Its activities are, among others, directed towards the management of protected natural areas; preservation of biological diversity of forest, aquatic and meadow ecosystems; regeneration and maintenance of natural forests; undertaking measures of protection of forests, nurseries and seed facilities against diseases, pests, and weed, protection of forests against fire, illegal utilization, etc. One of the activities is related to the protection and improvement of the state of the genepool of forest trees, which is very important from the aspect of FGR conservation. PE „Vojvodinašume” has cooperation with scientific and educational institutions, such as Faculty of Forestry, University of Belgrade, Institute of lowland forestry and environment, Novi Sad, etc.

National parks are protected areas managed by public enterprises, following the nature conservation and sustainable development principles. They are a significant factor in the FGR conservation, as *in situ* conservation objects. Additionally to nature conservation activities, PE NPs are managing state forests, and cooperating with public administration institutions in forestry, when it comes to different approvals, for example, consent to the management plans. They are cooperating with the Forest Directorate because they are obliged to register seed objects (nurseries) that are in their territory. Occasionally institutes and faculties are researching the territory of NP (Lalović, 2016). There are five PE NPs in Serbia (PE „NP Djerdap”, PE „NP Kopaonik”, PE „NP Tara”, PE „NP Fruška gora”, and PE „NP Šar-planina”).

NGOs – there are no concise data on the number of NGOs involved with nature and environmental protection, though there are assumed to be over 400. Some of the most active NGOs in Serbia include: „EcoDev”, „Endemit”, „Young Researches of Serbia” and „Green network of Vojvodina”. There are several international NGOs who also work in Serbia (such as International Union for Conservation of Nature, World Wildlife Fund (WWF-Adria Serbia)) whose activities are partly related to the issues of the FGR, primarily through the topics of nature and biodiversity conservation, sustainable forest management, climate change, etc. However, there are still no specialized NGOs involved in the conservation of the FGR. The impact of NGOs on the FGR conservation is mainly reflected in informative instruments, participation, and organization of public awareness campaigns, financing of projects, the publication of information materials, etc. (Lalović, 2016).

Education, research and training related to forest genetic resources in Serbia

The work of educational and research institutions related to the conservation of FGR is done through education as well as research and training within different projects and programs, at the national, regional and international levels. Several scientific-educational and research institutions are dealing with FGR and their conservation in Serbia.

Faculty of Forestry, University of Belgrade is a scientific-educational institution that, through its curriculum, directly contributes to the improvement of knowledge about conservation and directed utilization of the FGR.

At the ***Chair of seed science, nursery production and afforestation***, as part of Master Academic Studies, there is a special module entitled „*Plant Production and Conservation of Forest Genetic Resources*". Within this module, students gain knowledge, among other things, on the significance of the FGR and their conservation within the subject „Conservation and directed utilization of forest genetic resources", for which the same-titled textbook has been written (FOF, 2020). There is a ***Center for monitoring and conservation of forest genetic resources***, within the same Chair**,** which was established in 2007. The Center promotes the *in situ* and *ex situ* methods for the conservation and direct utilization of the gene pool of forest tree species, and improvement of the production of quality forest seed and plant material of controlled origin, as well as active participation in the European Forest Genetic Resources Program (FOF, 2020a). Also, the Chair has been conducted numerous studies on genetic diversity, intra- and inter-population variability of some of the most important forest tree species, etc. Various projects have been implemented to the conservation of rare and endangered species, as well as concrete activities related to the conservation of FGR, through the various *in situ* and *ex situ* methods, with research within master theses and doctoral dissertations related to this field. The Faculty of Forestry also performs tasks entrusted by the Ministry of agriculture, forestry and water management related to the certificate on the recognition of planting material, and control of seed sources and nurseries. The Faculty of Forestry has also played a significant role in the preparation of the National program for conservation and sustainable utilization of forest genetic resources of the Republic of Serbia for the period 2016-2025 (draft). Through concrete activities on the project with the same name, a draft of this Program was prepared, and its adoption and implementation are expected. The Faculty of Forestry is the manager of two protected areas: the monument of nature „Arboretum of the Faculty of Forestry" and the special nature reserve „Goč-Gvozdac".

Faculty of Biology, University of Belgrade is a scientific-educational institution in the field of biological sciences which deals with education in the area of FGR conservation in an indirect way. It is engaged in the conservation of the FGR through the management of the protected area (the monument of nature „Botanical Garden Jevremovac"). The ***Chair of plant ecology and phytogeography*** is engaged in education and scientific work in the field of the flora of vascular plants of the Balkan Peninsula, vegetation diversity as a very important aspect of plant biodiversity of Serbia and the Balkan Peninsula, and biodiversity protection. A part of the activities is directed towards *ex situ* conservation and reintroduction of endangered species to natural habitats (FB, 2020a). The overall goal of the ***Biodiversity Information Center***, within the Faculty of Biology, is to collect, organize, verify, analyze and distribute data on biodiversity in Serbia in a modern information-technology environment, based on dynamic online databases and GIS processing and presentation (FB, 2020).

Institute of forestry, Belgrade, is a research organization, which through scientific and professional work contributes to the improvement of the status of FGR. ***Department of genetics, plant breeding, seed, and nursery production*** researches the genetic potential of forest trees, as well as the diversity of forest and ornamental trees and shrubs (IF, 2020). The ***Department of forest protection*** carries out activities in the field of diagnostics of harmful organisms and protection of the health of forest plants on the territory of the Republic of Serbia[1] (IF, 2020a). Also, the Forest Directorate entrusted the Institute of forestry with the tasks of controlling seeds and production and the health status of nurseries

[1] Without the territory of the Autonomous Province of Vojvodina

in the territory of Serbia (Lalović, 2016). The Institute has been engaged in the preparation of the National Program for conservation and sustainable utilization of forest genetic resources of the Republic of Serbia for the period 2016-2025 (draft).

Institute of lowland forestry and environment, Novi Sad, is a research organization whose activities are directed towards applied research that seeks to solve practical problems of research users (public forestry enterprises, private forest landowners, urban residents, etc.); and fundamental (basic) research that lay down the foundation for the applied research. One of the main fields of research activities is genetics and breeding of forest and ornamental trees, including conservation of forest genetic resources. The Institute has realized numerous national and international projects related to the silviculture and sustainable forest management of various forest tree species, conservation of forest genetic resources, projects on the establishment of protective greenery, rehabilitation of degraded forest lands, forest protection, forest management plans, etc. (ILFE, 2020).

Institute for biological research „Siniša Stanković", University of Belgrade, is the leading multidisciplinary scientific institution in Serbia in the field of biological sciences which is indirectly engaged in the FGR conservation, through the work of the ***Ecology Division***, which carries out research focusing on the development, preservation, and functioning of biodiversity in relation to ecological processes and interactions with abiotic factors on the habitat (IBISS, 2020).

Institute of molecular genetics and genetic engineering, University of Belgrade, is one of the leading scientific research organizations in Serbia in the field of molecular genetics, biomedicine, and biotechnology. The teaching activity is realized mostly by the implementation of basic academic, master, and doctoral programs within the Faculty of Biology. The Institute indirectly works on FGR conservation, through the work of the ***Laboratory for molecular biology of plants***, which carries out researches on various aspects of the molecular biology of plants (examination of mechanisms of plant response to various factors of abiotic stress, research in the field of microevolution - population genetics, etc.) (IMGG, 2020).

Strategies relevant to forest genetic resources

Strategies that are directly or indirectly related to FGR and its conservation in Serbia are:

- Forestry development strategy of the Republic of Serbia (OG, 2006),
- National sustainable development strategy (OG, 2008),
- Biodiversity strategy of the Republic of Serbia for the period 2011-2018 (OG, 2011),
- National strategy for sustainable use of natural goods and resources (OG, 2012),
- National agriculture and rural development strategy of the Republic of Serbia for the period 2014-2024 (OG, 2014).

The **Forestry development strategy of the Republic of Serbia** (OG, 2006) represents the „*basic political and strategic development document of the forestry sector of Serbia which is based on the guiding principles of the sector, determines the development objectives, measures and methods of support for their implementation*" (Nonić D., 2015). As one of the strategic goals is defined: „*...conservation, realistic improvement, sustainable utilization and valorization of forest biodiversity*". Various measures are important from

the aspect of FGR conservation: improvement of the method for directed utilization of forest tree species genepools through *in situ* and *ex situ* conservation and improvement of the production of quality forest seed and planting material of controlled origin, as well as active participation in the European forest genetic resources programme; support the implementation of international obligations in the conservation of biodiversity in forest ecosystems (OG, 2006).

The **National sustainable development strategy** (OG, 2008), in addition to the richness of the genetic, species and ecosystem diversity in Serbia, states the basic problems related to the protection of national biodiversity. From the aspect of conservation of FGR, the most important goals in this strategy could be: improvement of the methods for sustainable use of genepool and establishment of the bank for the conservation of genetic material with increasing support for the conservation of genetic resources, as well as the increase in the number of subjects and areas involved in conservation work (OG, 2008).

The **Biodiversity strategy of the Republic of Serbia for the period 2011-2018** (OG, 2011) is a national strategic document in the field of nature protection, which is directly related to FGR. Objectives related to the conservation and sustainable utilization of FGR are: promoting the conservation of forest biodiversity, including genetic diversity, through the development of forest certification programs and best practices for sustainable forestry based on an ecosystem approach; development of forest management measures and guidelines for the prevention of adverse impacts of genetically modified tree species, allochthonous and invasive species on forests and biodiversity.

The **National strategy for sustainable use of natural goods and resources** (OG, 2012) as one of the general goals states „*...ensuring conservation, improvement of the state and sustainable use of populations of autochthonous species and communities at the level that will ensure their long-term viability*“ (OG, 2012). The specific goals related to the FGR are: maintaining genetic variability within populations and preserving their overall genepool, especially autochthonous plants; implementation of *ex-situ* and *in-situ* conservation measures; improving the capacity of the National gene bank; improving the management system for biological resources in protected natural assets, following the prescribed protection regimes.

The **National agriculture and rural development strategy of the Republic of Serbia for the period 2014-2024** (OG, 2014) as one of the key principles states responsible management of resources and their conservation for future generations, with better long-term biodiversity conservation, which is also related to genetic resources and includes plant, animal and forest genetic resources.

In addition to these strategies, there is a **Proposal of the Nature Conservation Strategy of the Republic of Serbia for the period 2019 to 2025**, in which forest genetic resources are directly mentioned. This document defines the overall objective - the improvement of the nature protection system and the specific objectives: biodiversity conservation, improvement of the system of protected areas and ecological networks, sustainable use of natural resources and promotion of public policy and public participation in decision making, as well as the appropriate measures (NCS, 2011).

Forests are particularly vulnerable to biotic and abiotic factors, which will be exacerbated by climate change. To reduce their impacts, sustainable forest management requires the adoption of practices that take into account scenarios for future climates. In addition to the aforementioned strategies, two strategies could be important for FGR conservation in Serbia.

Proposal of Low carbon development strategy of the Republic of Serbia with Action Plan (LCDS, 2019) is a climate change mitigation strategy which includes adaptation measures to highlight the vulnerability of the three priority adaptation sectors and their contribution to mitigation measures: agriculture, in terms of food production; forestry, from the aspect of bioenergy production; hydrology and water resources, in terms of electricity generation from water resources. One of the objectives is to increase carbon sink in Serbian forests by 17% by 2030 and between 22% and 132% by 2050, compared to 2010. Another objective related to forestry is to preserve the potential of mitigation measures, determined for 2030 and 2050 by increasing the resilience to climate change of the priority sectors climate resilience in priority sectors. The following measures need to be taken to achieve these objectives: afforestation using site mapping and climate change adapted tree species; introducing a „climate-smart forestry" approach; close to nature forest management approach; conversion of coppice to high forests; short-rotation forest plantations; research, training, and awareness-raising program, etc. PE „Srbijašume" and PE „Vojvodinašume", private forest owners and universities are recognized as stakeholders.

The Climate Change Communication Strategy (2017) is not directly related to forest genetic resources, but in this document states that, given the different impacts of climate change, the selection of tree species should be taken into account when planning adaptation measures for the forestry sector, as well as the fact that the afforestation will be increasingly difficult.

Legislation and regulations related to forest genetic resources

Several legally-binding and non-binding documents that affect the conservation of FGR were adopted in Serbia. The National program of conservation and sustainable utilization of FGR for the period 2016-2025 (draft) is expected to be adopted and is directly related to conservation and sustainable utilization of FGR.

Laws

Based on the review of national legislative frameworks, it can be noticed that there is no legally-binding regulation, that directly relates to the conservation of the FGR, but it is partly regulated in the area of environmental protection, nature protection, and forestry.

As laws that, in some of their parts, relate to the FGR and their conservation in Serbia, the following are distinguished:

- **Law on environmental protection** (OG, 2004) which emphasizes the protection and conservation of forests, biodiversity, and genetic resources;
- **Law on forest reproductive material** (OG, 2004a) which is indirectly significant due to control of production, recognition, traffic, etc. of forest reproductive material;

- **Law on nature protection** (OG, 2009b) which recognizes the importance of protecting, improving and preserving the biodiversity of forest ecosystems and conservation of genetic diversity;
- **Law on forests** (OG, 2010) which recognizes the conservation of forest trees genepool and diversity of forest ecosystems as a general-purpose forest function;
- **Law on national parks** (OG, 2015) which, among other things, refers to the protection and promotion of flora, vegetation, and forests.

The **Law on environmental protection** defines different protection principles. Based on this Law, the protection of biodiversity, use of biological resources and biotechnology, as well as the control of the input and growing of allochthonous species and regulation of traffic of endangered and protected species of wild flora and fauna is carried out (OG, 2004, §26).

The **Law on forest reproductive material** regulates „*...the conditions and method of recognizing the starting material for the production of reproductive material of forest trees, production, control of production, processing, quality, traffic and use of forestry reproductive material*“ (OG, 2004a, §1).

The **Law on nature protection** (OG, 2009b) regulates the protection, preservation, and improvement of biological, landscape, and geological diversity. The protection of biodiversity is achieved by implementing measures for the protection and improvement of species, their populations, natural habitats, and ecosystems (OG, 2009b, §15). The protection of forest ecosystems, according to this Law, is achieved by implementing appropriate measures and activities for their protection, improvement, and sustainable utilization (OG, 2009b, §18).

The **Law on forests** (OG, 2010) has made significant changes, both in terms of sustainable development of forests and forestry as an economic branch, as well as the operationalization of the goals set by the Forest development strategy (Nonić D., 2015). The Law, as a general-purpose function of forests, prescribes the conservation of genepool of forest trees and other species within the forest community, as well as the biodiversity conservation (OG, 2010, § 6). This Law regulates preservation, protection, planning, cultivation, and use of forests (OG, 2010, §1). According to §13, in order to conservation and sustainable utilization of genepool of protected species of forest trees, forest management plans should include measures for the protection, use, and extension of distribution of these species.

The **Law on national parks** (OG, 2015) aims to preserve and enhance the values of biodiversity, ecologically important areas, habitats, and populations of wild flora and fauna (OG, 2015, §2). National parks represent a significant form of *in-situ* conservation, so this Law can also be considered important from the aspect of FGR conservation.

In addition to the aforementioned laws, several laws could be important for biodiversity conservation. As the law that „*...tackles the problem of conservation and directed utilization of FGR*“ (Milovanović et al., 2012), can be specified the **Law on genetically modified organisms**, which regulates the procedure for issuing approval and conditions for „*...deliberately introduction into the environment of genetically modified organisms and products of genetically modified organisms*“ (OG, 2009a).

The **Law on agriculture and rural development** (OG, 2009) defines that rural development measures shall be the type of incentives that support the improvement of competitiveness in agriculture and forestry (investment in agriculture and forestry), improvement of environmental protection programs, preservation of biodiversity, etc.

Programs

From the aspect of FGR conservation, programs related to this field are also very significant. The National program on environmental protection is adopted in 2010, and the adoption of the National program for conservation and sustainable utilization of FGR of the Republic of Serbia for the period 2016-2025 (draft), is still expected.

In the **National program on environmental protection** different goals indirectly related to FGR are defined. Some of them are: improving the protection and sustainable use of wild plant species; implementing effective measures for controlling the introduction of genetically modified organisms; harmonization of national regulations in the field of nature, biodiversity and forest protection with European Union (EU) legislation and international conventions; establishing monitoring of biodiversity components; preserving, improving and extending existing forests; establishing synergies of sectoral policies and strategies; improving the protection of indigenous species and preventing the introduction of invasive species (OG, 2010a).

The **National program for conservation and sustainable utilization of FGR of the Republic of Serbia for the period 2016-2025 (draft)** provides an overview of the state in this area, defines the objectives, priorities and concrete conservation measures of FGR (Šijačić-Nikolić et al., 2016), and its implementation[2] is expected. The program was created as a result of the same project funded by the Ministry of Agriculture and Environmental Protection - Forestry Directorate, in its preparation were participated: University of Belgrade - Faculty of Forestry, Institute of Forestry in Belgrade and Institute of Lowland Forestry and Environment from Novi Sad. The program consists of various chapters, among which are: factors that threaten FGR, the legal framework for conservation and sustainable utilization of FGR, the state of FGR in Serbia and previous activities for FGR conservation, etc. whereby the chapter „*Climate change and conservation of forest genetic resources*“, in which priorities and measures for conservation of forest genetic resources in line with climate change are defined, is particularly significant (Šijačić-Nikolić et al., 2016). The Program predicts the activities, which are expected to have an impact on: development of the forestry sector; improvement of forest management; informing the general public about the need to conserve FGR; compliance with international obligations and the possibility of joining activities within the FAO organization related to FGR (Šijačić-Nikolić et al., 2016; Nonić et al, 2017a). Since it is not prescribed as a binding legal act under the current Law on Forests (OG, 2010) and is important for preserving Serbia's FGR „*...it is necessary to ensure its implementation in a way that all relevant entities in the Republic of Serbia, within their competences, commit to its implementation*” (Šijačić-Nikolić, Sovilj, 2017). The need for implementation of documents aimed at the conservation and enhancement of natural resources (including FGR) undertake both domestic and international processes and agreements.

[2] National Program of conservation and sustainable utilization of FGR of the Republic of Serbia for the period 2016-2025 (draft) is officially posted on the website of the Forest directorate: https://www.upravazasume.gov.rs/wp-content/uploads/2016/10/Nacrt-nacionalne-strategije-konzervacije-sumskih-genetickih-resursa.pdf

In addition to these programs, a document that may be indirectly considered important in terms of forest genetic resources conservation is the draft of the first **National climate change adaptation plan for the Republic of Serbia** (2015-2020). This document as one of its main objectives has an analysis of future risks and vulnerabilities in selected sectors (water resources, agriculture, forestry and biodiversity) concerning the future climate scenarios presented in the first and second reports of Republic of Serbia to the United Nations Framework Convention on Climate Change, which will enable identification of priority adaptation measures. Priority measures that contribute to the reduction of risk related to possible future climate change in the field of forestry, are: the establishment of new forests, construction of new forest roads and improving the quality of forests.

Decrees and rulebooks (sub-legal acts)

In addition to laws, strategies, and programs, various decrees and rulebooks were adopted in Serbia, which are in some parts related to the conservation of genetic resources. Below are listed some of the more significant sub-legal acts, from the aspect of FGR conservation. **Decree on putting under control the use and trade of wild flora and fauna** determines „*...wild species of flora, fauna and fungi whose collection from natural habitats, use and trade are placed under control*" (OG, 2005, §1).

Rulebook on the transboundary movement and trade in protected species prescribes, inter alia, the conditions under which are performed „*...import, export, entry, amount or transit, trade and cultivation of endangered and protected plant and animal wild species, their parts and derivatives*" (OG, 2009e, §1).

By the **Rulebook on declaration and protection of strictly protected and protected wild species of plants, animals and fungi** are declared wild species of plants, animals, and fungi, to „*...conserve biological diversity, natural genepool*" as strictly protected wild species or protected wild species and are determined the measures of their protection and protection of their habitats (OG, 2010c, §1).

In **Rulebook on conditions for establishing a gene bank of wild plants, animals and fungi, the manner of work of gene bank, manner of handling biological material, content of applications and documentation to be submitted with the application for the issuance of permit for establishing a gene bank**, in §3, state that research and preservation of biological material for the needs of gene bank may be carried out „*in situ - which implies the research and preservation of genetic material in the ecosystem or natural habitat and the maintenance and restoration of a sustainable population of species in their natural environment; and ex situ - research and preservation of genetic material outside its natural habitat*" (OG, 2010b). According to the Rulebook, the use of biological material must not endanger the survival of wild plant populations (OG, 2010b, §3).

Needs, challenges and opportunities for strengthening the national institutions and policies on forest genetic resources

Recognizing the problem and importance of conserving biodiversity and genetic diversity in the analyzed documents in the field of forestry, environmental protection and nature protection in Serbia, indicates the existence of intentions for the prevention of various threatening factors. However, there is an insufficient commitment to the category of FGR,

since, in Serbia, there are still no adequate, legally binding, legislative frameworks directly related to this field. If FGRs are not directly mentioned in the national regulatory frameworks, there is the risk that they may be overlooked, so there is a need to define the terms „*forest genetic resources*“ and „*conservation of forest genetic resources*” in the existing laws in the field of forestry, nature protection, and environmental protection.

✓ Weakness: Insufficient formal and informal education in the conservation of FGR
Priority objectives: The first objective is improving formal education in the conservation of forest genetic resources and introducing specific themes into curricula at all levels of education, not only at the Faculty of Forestry, Belgrade. There is a need to develop guidelines for introducing specific themes on FGR conservation into curricula of primary and secondary education; develop a synthesis report on the representation of FGR conservation topics in curricula of higher education with defined measures for improvement; develop databases of experts' capacities and potentials in the area of FGR conservation. The second priority objective is improving informal education in FGR conservation and cooperation with the civil sector. There is a need to develop databases of civil sector capacities for education and dissemination activities in the area of forest genetic resources conservation; capacity assessment of protected natural areas managers and forest owners and users for implementation of FGR conservation programs and definition of improvement measures; develop a long term program of integration of research, experts and civil society capacities with the aim of improvement in the area of FGR conservation education. There is a need to develop collaboration and promote coordination of national institutions and programs related to FGR. The third priority objective is to reinforce regional and international cooperation, including networking, to support education, knowledge dissemination, and research.

✓ Weakness: Insufficient cooperation between institutions and organizations.
Priority objectives: To build and implement a policy of cross-sectoral dialogue for the successful implementation of FGR conservation activities. There is a need for continuous cooperation and information exchange between institutions and organizations working in the field of forestry, nature conservation, and environmental protection is necessary.

✓ Weakness: Insufficient resources for research activities related to FGR conservation.
Priority objectives: Strengthen efforts to mobilize the necessary resources, including financing, for the conservation, sustainable use, and development of FGR. There is a need for financing a larger number of scientific-research projects for *in situ* and *ex situ* conservation of endangered, rare, relict, and endemic forest tree species and their monitoring.

✓ Weakness: Lack of specific strategic framework for FGR conservation.
Priority objectives: Improvement of the strategic framework for FGR conservation. It is important to improve the strategic goals of forestry development with an emphasis on the holistic approach to forest management. There is a need for improvement of the strategic framework in the environment and nature protection, to improve the status of FGR conservation, and to establish an *ad hoc* expert group for monitoring of this status.

✓ Weakness: Lack of specific legal framework for FGR conservation.
Priority objectives: Improvement of the legal framework for FGR conservation. There is a need to harmonize the legal frameworks in the management of forest reproductive material

with the expected intensity of changes in environmental conditions and the needs of assisted migration of genetic material following the intensity of climate change; assess the existing legal framework for regions of the provenance of forest tree species with the needs of adjusting and mitigating the consequences of changes in the environmental conditions; to improve existing by-law framework with the aim of integration of forest genetic resources conservation into the system of regular forest management. It is important to improve the status of FGR conservation in the legal framework for environmental protection and nature conservation.

- ✓ Weakness: Lack of adoption and implementation of the specific program for conservation and sustainable utilization of FGR.

Priority objectives: Implementation of National program for conservation and sustainable utilization of FGR of the Republic of Serbia for the period 2016-2025 (draft). The draft of such a document was prepared and its adoption and implementation could make a step forward in resolving the problems determined in the lack of appropriate regulatory frameworks related to the conservation and sustainable utilization of FGR in Serbia.

Priorities for capacity building in this area

One of the priorities is the capacity building of state and public sector for FGR conservation. There is a need to:

- Develop a long-term training program for representatives of the state and public forestry sector to strengthen the capacity to conserve FGR;
- Prepare educational materials and improve the knowledge of employees in state administration and public enterprises about the necessity of harmonizing forest management with goals of FGR conservation;
- Provide equipment and improve the skills of employees in public enterprises for the application of modern software packages for modeling ecosystem processes concerning changes in environmental conditions.

The second priority is strengthening the capacities of the private and civil sectors in the conservation of FGR. Within the second priority, it is important to:

- Develop a long-term training program for representatives of the private and civil sector to strengthen the capacity to conserve FGR;
- Prepare educational materials and improve the knowledge and skills of representatives of the private and civil sector on the importance of FGR conservation;
- Identify all stakeholders in the process of programming and planning the FGR conservation and actively involve them.

People's participation is essential in almost all conservation actions, especially for the development of *in situ* conservation strategies and programs. The main stakeholders in a conservation process are landowners and users, biomass industry and nursery production, scientific organizations, civil society organization active in the field of environmental protection and nature conservation, media and, local community. Conservation of plant species requires that stakeholders trust one another and commit themselves to the task of sustainable use of natural resources. Landowners and users of the land, including members of the local community, can play a very important role in the process of preserving the adaptability of the species and its adaptation to the new environmental conditions due to global climate change.

The role of scientific institutions is precisely to enable a better understanding of the existing level of intraspecies and individual variability of the plant species, to establish the relationship between genetics and economically important traits of individuals and to contribute to the conservation of species in commercial flows through their research. Civil society organizations and media have a crucial role in raising public awareness of the importance of species conservation for present and future generations. The local community gets the opportunity to preserve its environment and make it more pleasant not only for its own life but also for a large number of tourists, with stable ecosystems of their region gaining economic valorization (Šijačić-Nikolić, Milovanović, 2019).

The third priority is raising public awareness and disseminating information in the *in situ* and *ex situ* conservation of FGR. There is a need to:

- Develop informative and educational material on regional networks of conservation areas and the importance of *in situ* conservation of FGR;
- Integrate forest conservation areas and conservation programs into educational and tourist activities of protected natural areas;
- Map *ex situ* conservation points and develop educational and information program for acquaintance with this form of preservation of genetic variability of forest species;
- To promote *ex situ* conservation of FGR through good practice from all countries of Southeast Europe;
- Develop an internet portal on the importance of FGR with the presentation of all *in situ* and *ex situ* conservation capacities.

CHAPTER 12. INTERNATIONAL AND REGIONAL COOPERATION ON FOREST GENETIC RESOURCES

Relevant strategic, legal and program documents at the national level recognize the importance of Serbia's active participation in international processes related to the conservation of biodiversity and genetic resources. The National Program for conservation and directed utilization of forest genetic resources of the Republic of Serbia for the period 2016-2025 (draft) as one of its priorities states „*fulfillment of international commitments related to this field*" and „*the need to continue the active participation of national institutions and organizations in international processes and initiatives related to the conservation of forest genetic resources*", and measures within this priority specify in more detail future directions in this area. One of the general goals of this program is to define specific goals, priorities, and measures for international and cross-sectoral cooperation in the conservation of FGR.

The Republic of Serbia is a signatory of different international treaties related to biodiversity and nature protection that affect the forestry sector.
Some of the ratified international agreements that are significant for the forestry sector are:

- Agenda 21;
- Convention on Biological Diversity (CBD) and its Cartagena Protocol;
- United Nations Framework Convention on Climate Change (UNFCCC);
- Resolutions of the Ministerial Conference on the Protection of Forests in Europe (MCPFE);
- Convention on Long-range Transboundary Air Pollution (CLRTAP);
- Convention on Wetlands (Ramsar Convention);
- Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES);
- Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention);
- Convention concerning the Protection of the World Cultural and Natural Heritage;
- Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity.

One of the ratified international treaties, which is essential for the improvement of the conservation of biodiversity and genetic resources in Serbia, is the Law on Ratification of the Convention on Biological Diversity, by which Serbia has accepted a range of international commitments in the field of genetic diversity conservation.

Serbia is a signatory of bilateral agreements on cooperation in the field of environment protection and nature conservation. Some of the documents signed since 2013 are:

- Agreement between the Government of the Republic of Serbia and the Government of the Republic of Croatia on cooperation in the field of environmental protection (2015);
- Memorandum of Understanding and Cooperation in environmental protection between Serbia and Korea (2018);
- Memorandum of Understanding and Cooperation in environmental protection between Serbia and Italy (2019);
- Agreement on Cooperation between national parks in Serbia and Italy (2019);

- Memorandum of Cooperation on environmental protection between Serbia and Greece (2019);
- Memorandum of Understanding between the Bulgarian Ministry of environment and water and the Ministry of environmental protection of the Republic of Serbia on cooperation in the field of environmental protection (2019);
- Agreement between the government of the Republic of Bulgaria and the government of the Republic of Serbia on an early exchange of information in case of radiation accident (2019);
- Cooperation Agreement between the Government of the Republic of Serbia and the Government of Hungary on Environmental Protection (2019), etc.

The following sub-chapters will outline some of the most important international and regional activities in the field of FGR, membership in international organizations, as well as some of the projects implemented since 2013 that are related to the FGR and/or conservation of biodiversity.

International cooperation on forest genetic resources, benefits and results

The Republic of Serbia is a member of the **European Forest Genetic Resources Programme (EUFORGEN)**, an international cooperation programme that promotes the conservation and sustainable use of forest genetic resources in Europe as an integral part of sustainable forest management.

In April 2019 the Steering Committee finalized the strategic objectives and the implementation plan for 2020-2024, setting out proposed activities, results and the budget. During Phase VI (2020-2024), EUFORGEN will work towards three strategic objectives (EUFORGEN, 2020):

1. Facilitate knowledge sharing and communicate with key stakeholders;
2. Coordinate the implementation of the conservation of forest genetic resources in Europe;
3. Promote the appropriate use of forest genetic resources.

Serbian national priorities in the area of FGR conservation are in line with these internationally accepted objectives.

In addition to EUFORGEN, Serbia is a member of the **European Cooperative Programme for Plant Genetic Resources (ECPGR).** It is a collaborative Programme among most European countries, aiming at ensuring the long-term conservation and facilitating the utilization of plant genetic resources in Europe. The Programme operates through various Working Groups dealing with groups of crops, but also with general themes related to plant genetic resources. It is not directly related to FGR, but there is a working group ***Wild Species Conservation in Genetic Reserves*** where Serbian experts are actively engaged (ECPGR, 2020).

The Republic of Serbia is one of the signatory countries within the **FOREST EUROPE**, the brand name of the Ministerial Conference on the Protection of Forests in Europe. FOREST EUROPE develops common strategies for its 47 signatories (46 European countries and the European Union) on how to protect and sustainably manage their forests (FEU, 2020).

The FOREST EUROPE process periodically hosts ministerial-level conferences where ministerial commitments and resolutions are adopted. At the 7th Forest Europe Ministerial Conference on the Protection of Forests in Europe (2015), signatory countries (including Serbia) committed to "*continuing pan-European collaboration on forest genetic resources through EUFORGEN, which is a clear recognition of EUFORGEN's effectiveness and its role in conserving forest genetic diversity and contributing to sustainable resource management*" (EUFORGEN, 2020a).

Three educational and research institutions from Serbia (Faculty of Forestry-University of Belgrade, Institute of Forestry, Belgrade, and Institute of Lowland Forestry and Environment) are members of the **International Union of Forest Research Organizations (IUFRO)**. The IUFRO's field of scientific activity is spread over 9 divisions (IUFRO, 2020). Serbian researchers actively participate in IUFRO activities and implement the results on the national level.

Within Division 2 – *Physiology and genetics*, there is a unit 2.04.01 - ***Population, ecological and conservation genetics*.** Genetic conservation is a prime focus of this unit, whose interest includes research on genetic diversity (IUFRO, 2020a).

Within Division 6 – *Social aspects of forests and forestry*, there is a unit 6.04.00 - ***Nature conservation and protected areas*** which refers to designated locations that receive conservation or protection because of their recognized natural and/or cultural values (IUFRO, 2020b).

Within Division 8 – ***Forest environment***, there is a unit 8.02.00 - ***Forest biodiversity*** which aims to determine how forest biodiversity is influenced by anthropogenic and natural disturbance and explore the relationship between forest biodiversity, ecosystem functioning, and resilience in the context of sustainable forest management (IUFRO, 2020c).

European Forest Institute (EFI) is an international organization established by the European states, which currently has 122 member organizations from 38 countries. Three educational and research institutions from Serbia (Faculty of Forestry-University of Belgrade, Institute of Forestry, Belgrade, and Institute of Lowland Forestry and Environment) are EFI member organizations (EFI, 2020).

The **International Union for Conservation of Nature (IUCN)** is an active inter-governmental organization on a global level that counts over 1,300 members from over 170 countries. Through its forest initiatives, IUCN helps countries implement effective forest policies, achieve national priorities and meet international commitments on climate change, biodiversity and land degradation. Three institutions from Serbia are IUCN members: Ministry of environmental protection of the Republic of Serbia, Institute for nature conservation of Serbia and Institute for nature conservation of Vojvodina Province (IUCN, 2020).

United Nations Development Programme (UNDP) works in Serbia, guided by its Country Programme Document (2016-2020), and the UN-Serbia Development Partnership Framework for 2016-2020, which is in line with the priorities of the Government of Serbia and the 2030 Agenda for Sustainable Development.

UNDP assists Serbia to meet its international obligations and requirements for the European Union accession (UNDP, 2020).

The **Regional Environmental Center for Central and Eastern Europe (REC)** is an international organization with a mission to assist in addressing environmental issues. Since July 2008, REC Serbia has operated based on a cooperation agreement between the Republic of Serbia and the Regional Environmental Center for Central and Eastern Europe, signed by the Government of Serbia and the REC (REC, 2020).

The Republic of Serbia has cooperation with the **Food and Agriculture Organization (FAO)**. The partnership between Serbia and FAO began in 2001, and its assistance in Serbia contributes to two priority areas identified by the Government and the UN Country team, namely: economic development, growth and employment, and environment, climate change and resilient communities (FAO, 2020a).

One of the benefits of international cooperation is data obtained from the **European Information System on Forest Genetic Resources (EUFGIS)**. EUFORGEN developed this system that supports countries in identifying gaps in conservation of forest species and in setting priorities to fill these conservation gaps, it can be used by countries as a national information system. A total of 36 countries, including Serbia, have nominated a national focal point to EUFGIS, and „a*s of today, the EUFGIS database contains information on 3595 units and 108 tree species in 35 countries. The units harbor a total of 4318 tree populations*" (EUFGIS, 2020).

There are other kinds of cooperation between institutions which are dealing with FGR on the international or regional level, through different projects. There are different exchange mobility programs for teachers, such as CEEPUS, Erasmus+, etc. where scientists from Serbia can visit institutions, work in laboratories, share experiences, and knowledge with colleagues from other European countries. Serbian institutions that are working on FGR share information with some European institutions. Some research works of Serbian scientists on FGR are the result of international and regional cooperation and are presented at national and international scientific congresses, conferences, symposia. Results obtained from research on FGR conducted in Serbia are published in different international scientific journals, as well as chapters in international monographs.

Regional cooperation on forest genetic resources, benefits and results

Most of the countries of Southeast Europe are members of the aforementioned EUFORGEN, IUFRO, EFI, IUCN, etc. so regional cooperation in the field of FGR conservation has been established and activities are coordinated. Different institutions from European countries are involved in the work of numerous COST Actions.

World Wide Fund for Nature (**WWF) Adria** works in Serbia and most of the Southeast European countries: Croatia, Bosnia and Herzegovina, Montenegro, Albania, North Macedonia, and Slovenia. It was officially established at the beginning of 2015, with head office in Croatia. WWF Adria's goal is to preserve the natural environment, biodiversity and ecological processes in the Mediterranean region and the Dinaric Arc area (WWF ADRIA, 2020).

A kind of regional cooperation on FGR is realized through the organization of **Inter-Chair Meetings** of teachers, researchers, and associates in the field of forest genetics, plant breeding, conservation of FGR, seed science, nursery production, afforestation, as well as wood anatomy. The Faculty of Forestry at the University of Banja Luka (Bosnia and Herzegovina), by initiating and organizing Inter-Chair Meeting in 2016, continued the tradition that was broken more than 25 years ago. Representatives of the scientific-educational and research institutions from Bosnia and Herzegovina, Serbia, Croatia, Slovenia, and North Macedonia agreed on joint activities: exchanging information about the yield of the most important forest tree species; conducting common experiments, and writing an international monograph on the impact of climate change on forest genetic resources. The second Inter-Chair Meeting was held in 2018, in Serbia, in the Teaching base of Faculty of Forestry in Goč Mountain. The organizers of the meeting were the Chair of seed science, nursery production and aforestation from the Faculty of Forestry, University of Belgrade, and the Department of genetics, plant breeding, seed, and nursery production from the Institute of Forestry in Belgrade. Meeting participants, representing 10 institutions from Serbia, Bosnia and Herzegovina, Croatia, Slovenia, and North Macedonia, discussed the possibilities of applying for joint projects, the exchange of acquired knowledge and experience within the existing laboratories, the exchange of plant material. An initiative has been launched to apply for a joint CEEPUS program (*Central European Exchange Program for University Studies*), for the exchange of students, teachers, and associates. The tradition of Inter-Chair Meetings will be continued, and the meetings will be organized once in two years.

One of the results from regional and international cooperation on FGR is a **book „*Forests of Southeast Europe under a changing climate: conservation of genetic resources*"**, published in 2019 by Springer Nature Switzerland AG, Cham (Šijačić-Nikolić et al., 2019). Editors of this book, from Serbia, invited authors from 28 various scientific institutions from 9 countries of Southeast Europe (Bosnia and Herzegovina, Bulgaria, Croatia, Greece, North Macedonia, Montenegro, Romania, Serbia, and Slovenia) to contribute. The initial idea for writing this book was presented at the first Inter-Chair Meeting in Banja Luka. This book aimed to point out the significance and potential of forest genetic resources in the countries of Southeastern Europe, bearing in mind that this is an area with pronounced biodiversity and significant forest cover. The book elaborates current state and legal and institutional framework for forest genetic resources conservation, *in situ* and *ex situ* conservation case studies from Southeast Europe, as well as climate change aspects in forest genetic resources conservation. Looking at the current state, with the desire to improve it, concluding remarks and recommendations have been defined as a separate chapter which consists of objectives, priorities, and measures for conservation of forest genetic resources of Southeast Europe under a changing climate in the future. Authors of different book chapters (66 authors), presented the state and current activities for the conservation of FGR in the countries of Southeast Europe. According to the current state, goals, priorities and concrete measures were defined, as guidelines for improving this area.

The result of regional cooperation is a **CEEPUS network CIII-BA-1403-01-1920 „*Managing forests for climate change*"** (2019-2022), which includes, as partners, Faculties of Forestry in the region (Bosnia and Herzegovina, Croatia, North Macedonia, Slovenia, and Serbia) as well as the Institute for Molecular Genetics and Genetic Engineering of the University of Belgrade, and the Institute for Lowland Forestry and Environment of the University of Novi Sad.

The project coordinator is the University of Banja Luka, Faculty of Forestry (Republic of Srpska, Bosnia and Herzegovina). The networking of researchers in the area of Former Yugoslavia, as well as the whole Southeastern Europe, is of particular importance because this area is under threat and threatens drastic changes in vegetation according to existing climate models. This network has several aims: to exchange knowledge and practices between professors and researchers; organization of seminars and international conferences on this topic; publishing joint papers in leading journals; printing joint publication; an overview and changes of existing curricula; development of a single (joint) program for MSc and/or Ph.D. studies; support development of doctoral thesis for which the students will use the resources from different laboratories (CEEPUS, 2020). Several mobility changes for teachers have successfully finished in 2019, and further cooperation will continue.

Projects on forest genetic resources

Serbian experts participated as stakeholders at different workshops related to FGR conservation, organized within international projects, such as Horizon 2020, LIFE+, COST Action, etc. Researchers from Serbia awarded different international grants for summer schools, workshops, short time scientific missions (STSMs), related to FGR.

The European Commission introduced a financial Instrument for Pre-Accession Assistance (IPA funds) for the budgeting period 2007-2013 (IPA I), which supported EU candidate countries and potential candidate countries. The Republic of Serbia has access to the first two IPA components: support to transition process and development of institutions and regional and cross-border cooperation (IPA, 2020). In addition to IPA funds, the Republic of Serbia obtains certain funding for projects from donations, international assistance funds, loans, UN funds, programmes and funds of international organizations, such as the Global Environmental Facility (GEF), the United Nations Development Programme (UNDP), the United States Agency for International Development (USAID), the German Organization for Technical Cooperation (GTZ); as well as 7th Framework Programme for Research and Technological Development (FP 7) and Horizon 2020. List of projects on FGR or conservation of biodiversity and environment implemented since 2013 is presented in Table 12.1.

Horizon 2020 project **GenRes Bridge („*Genetic resources for forested and food-secure Europe*")** held a „*Sharing Perspectives Workshop*" in Tuusula, Finland (2019). The participants from 57 stakeholder organizations from 26 countries (including Serbia), represented expertise on a broad range of issues in three domains of genetic resources: crops, animals and forests. The objectives of the workshop were: „*to share the present strategies and programmes with one another and to analyse gaps, overlaps and synergies; to generate and present an overview of existing policies with special emphasis on the links between the three domains of animals, crops and forests and on policies regarding biodiversity; to identify elements for developing the integrated conservation strategy for GenRes in Europe*" (GenRes Bridge, 2019).

Table 12.1. Projects on FGR or conservation of biodiversity and environment since 2013

Project title	Start	End
CEEPUS - Central European Exchange Program for University Studies		
Managing forests for climate change	2019	2022
COST - European Cooperation in Science and Technology		
COST Action: Pan-European network for climate-adaptive forest restoration and reforestation (PEN-CAFoRR)	2020	2024
COST Action CA18201: An integrated approach to conservation of threatened plants for the 21st Century (ConservePlants)	2019	2023
COST Action CA18111: Genome editing in plants - a technology with transformative potential (PlantEd)	2019	2022
COST Action CA18134: Genomic biodiversity knowledge for resilient ecosystems (GBIKE)	2019	2023
COST Action CA18207: Biodiversity of temperate forest taxa orienting management sustainability by unifying perspectives (BOTTOMS-UP)	2019	2023
COST Action CA16208: Knowledge conversion for enhancing management of European riparian ecosystems and services (CONVERGES)	2017	2021
COST Action CA15223: Modifying plants to produce interfering RNA (iPLANTA)	2016	2020
COST Action CA15226: Climate-smart forestry in mountain regions (CLIMO)	2016	2020
COST Action FP1406: Pine pitch canker: strategies for management of *Gibberella circinata* in greenhouses and forests (PINESTRENGTH)	2015	2019
COST Action FP1304: Towards robust projections of European forests under climate change (PROFOUND)	2014	2018
COST Action ES1308: Climate change manipulation experiments in terrestrial ecosystems: networking and outreach (ClimMani)	2014	2018
COST Action FP1305: Linking belowground biodiversity and ecosystem function in European forests (BioLink)	2014	2018
COST Action FP1401: A global network of nurseries as early warning system against alien tree pests (Global warning)	2014	2018
COST Action FP1403: Non-native tree species for European forests-experiences, risks and opportunities (NNEXT)	2014	2018
COST Action FP1204: Green infrastructure approach: linking environmental with social aspects in studying and managing urban forests (GreenInUrbs)	2013	2017
COST Action FP1206: European mixed forests-integrating scientific knowledge in sustainable forest management (EuMIXFOR)	2013	2017
Interreg - EU Interreg Danube Transnational Programme		
Resilient riparian forests as ecological corridors in the Mura-Drava-Danube Biosphere Reserve (REFOCuS)	2018	2021
Interreg IPA Cross-border Cooperation Programme Croatia – Serbia 2014-2020		
Integrated Cross-Border Monitoring and Management Systems for Flood Risks, Environmental and Biodiversity Protection and Forestry Through Transboundary Forest Retentions and Other Measures (FORRET)	2017	2020
IPA - EU Instrument for Pre-Accession Assistance		
IPA Cross-border cooperation Hungary - Serbia: Natural selfness (NATESS)	2018	2020
IPA Cross-border cooperation Croatia - Serbia: Flood protection infrastructure restoration and development of cross-border system for protecting people and natural assets from floods	2016	2018
IPA Cross-border cooperation Hungary - Serbia: Oxidative stress tolerance in plants: from models to trees (OXIT)	2013	2017
EFI - European Forestry Institute		
Forest management scenarios for adaptation and mitigation (FORMOSAM)	2018	2020
REC – Regional Environmental Center for Central and Eastern Europe		
Addressing the Risks of Forest Fires in South-Eastern Europe	2013	2015
UNDP - United Nations Development Programme and GEF - Global Environment Fund		
Establishing Transparency Framework for the Republic of Serbia (CBIT)	2019	2021
Capacity Development for Improved Implementation of Multilateral Environm. Agreem.	2017	2021
Climate Smart Urban Development Challenge	2017	2021
Ministry of Science and Technology, Government of the Republic of Srpska		
Defining strategies for *in situ* and *ex situ* conserv. of Serbian spruce with respect to CC	2019	2020

Genetic Conservation subgroup (GenCon) was formed in 2018 within Working Group 2 (WG 2) of **COST Action CA16208 „*Knowledge conversion for enhancing management of European riparian ecosystems and services*"**. Scientists from Serbia are members of this subgroup, which has several aims: review the state of art in genetic conservation of riparian ecosystems/species at the European level; promote knowledge transfer of recent scientific developments into the practice; identify knowledge gaps, conservation barriers and future research and management needs (CONVERGES, 2019). Workshop „*Visualisation of European responses to riparian vegetation degradation*" was held in Belgrade (Serbia), in 2019. One of the subgroup members from Serbia awarded a grant for STSM at the University of Lisbon, where different activities were done, such as reviewing the literature, organizing questionnaires on riparian genetics conservation in Europe, and data analysis.

COST Action CA18134 „*Genomic Biodiversity Knowledge for Resilient Ecosystems*" (G-BIKE) organized a workshop for practitioners and scientists „*New developments in the field of genomics technologies for solving practical conservation issues*" in Slovenia (2020). There were 20 participants from different countries, including the participant from Serbia. Four topics were addressed: genetic engineering in endangered populations; biotechnology approaches *in situ* and *ex situ*; controlling invasive species and managing populations; synbio applications in conservation (G-BIKE, 2020).

The Institute for Lowland Forestry and Environment from Novi Sad (Serbia) has organized a seminar in 2019 within the Life+ project **„*Life for European Forest Genetic Monitoring System*" (LIFEGENMON)**, which was attended by representatives of the Slovenian Forestry Institute and various educational and scientific-research institutions, and public enterprises from Serbia. The results of the LIFEGENMON and SIFORGEN projects, as well as of the EUFORGEN Working group on forest reproductive material were presented during the seminar. An overview of the National program for conservation and sustainable utilization of FGR of the Republic of Serbia for the period 2016-2025 (draft) is presented (LIFEGENMON, 2019).

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

- ✓ Weakness: Insufficient coordination of international and regional cooperation activities on FGR conservation at the national level.

Priority objectives: The first objective is an improvement of coordination of international and regional cooperation activities on FGR conservation, at the national level. The priority is the continuation of the active participation of national institutions and organizations in international processes and initiatives related to the conservation of FGR. It is important to adopt and actively implements all recommendations of the MCPFE process. There is a need to continue active participation in the EUFORGEN Program and adopt all recommendations for improving national strategic and legal frameworks. Developing a long-term action plan for the participation of national institutions in international processes and fulfill international recommendations and guidelines is of great importance.

- ✓ Weakness: Insufficient monitoring and implementation of international initiatives on FGR conservation.

Priority objectives: The priority is monitoring and implementation of international initiatives and standards in the field of FGR conservation. It is important to establish an *ad hoc* expert group for monitoring international movements in the field of FGR conservation; encourage institutional and expert involvement in international networks for evaluating FGR conservation; develop guidelines for the introduction of international recommendations for FGR conservation in national and regional strategic and legal frameworks.

PART 6

CHALLENGES AND OPPORTUNITIES

PRIORITY A: Availability of information on forest genetic resources		
Challenge A To systematize available information on FGR and make user-friendly publications to provide a basis for state assessment, monitoring, conservation and sustainable use	**Opportunity A.1.** Updated information on the state of diversity between trees and other woody plant species and defined trends in the number of species	**Recommended Action A.1.1.** *To collect detailed information on FGR diversity during the ongoing process of forest inventory (2020)*
		Recommended Action A.1.2. *To develop a comprehensive database on FGR diversity followed by a detailed description of the species and to make it available online and user-friendly for all relevant stakeholders*
	Opportunity A.2. Updated information on the state of diversity within trees and other woody plant species and defined trends of variability for important species	**Recommended Action A.2.1.** *To systematize information and research results on FGR intra-specific variability from published papers and project reports at the national level*
		Recommended Action A.2.2. *To define trends of FGR intra-specific variability for important species and to make it available online and user-friendly for all relevant stakeholders*
	Opportunity A.3. Updated information on the current practices in FGR conservation (*in situ* and *ex situ*) at the national level	**Recommended Action A.3.1.** *To develop a synthesis report on FGR conserved applying in situ and ex situ methods and make it available online and user-friendly for all relevant stakeholders*
		Recommended Action A.3.2. *To prepare and publish manuals on the manner of implementation of specific FGR in situ and ex situ conservation measures and make it available online and user-friendly for all relevant stakeholders*
	Opportunity A.4. *Integrated forest conservation areas and conservation programs into educational and tourist activities of natural protected areas*	**Recommended Action A.4.1.** *To prepare and publish educational materials and tourist guidelines on FGR conservation and make it available for visitors to natural protected areas*
		Recommended Action A.4.2. *To develop scientific and educational paths within protected areas and mark FGR conservation points with user-friendly information tables*

PRIORITY B: Conservation of forest genetic resources		
Challenge B To implement, monitor and evaluate all the activities defined within the "National program for conservation and sustainable utilization of FGR of the Republic of Serbia for the period 2016-2025" (NPFGR); To integrate species-specific approach to FGR conservation	**Opportunity B.1.** National program for conservation and sustainable utilization of FGR of the Republic of Serbia for the period 2016-2025 is officially adopted and implemented	**Recommended Action B.1.1.** *To adopt the National program as an official document at the national level*
		Recommended Action B.1.2. *To initiate implementation of all measures defined in the National program and to develop monitoring and evaluation indicators*
	Opportunity B.2. Financial resources allocated for implementation of all measures defined in the National program for conservation and sustainable utilization of FGR of the Republic of Serbia for the period 2016-2025	**Recommended Action B.2.1.** *To develop multi-year conservation project proposals following objectives, priorities and measures defined in the National program and define possible financial sources/donors*
		Recommended Action B.2.2. *To initiate implementation of multi-year conservation projects supported by the Government and other donors*
	Opportunity B.3. A national list of FGR important species defined and species-specific technical guidelines developed	**Recommended Action B.3.1.** *To develop guidelines for priority species identification and involvement in the programs of intensive research*
		Recommended Action B.3.2. *To develop species-specific technical guidelines and include this approach in forest conservation*
	Opportunity B.4. "Common action plans" for FGR priority species developed and aim at sharing responsibilities in FGR conservation among the regions and stakeholders.	**Recommended Action B.4.1.** *To improve information management and obtain geo-referenced data on the existing gene conservation units of FGR priority species throughout their entire distribution ranges in the country*
		Recommended Action B.4.2. *To develop "common action plans" for FGR priority species and to integrate them in forest management systems*

PRIORITY C: Use, development and management of forest genetic resources		
Challenge C To comprehensively valorize FGR in urban and rural areas including all forest functions and benefits; To develop long-term national breeding program for FGR; To integrate FGR conservation and species-specific approach to forest management	**Opportunity C.1.** In-depth survey on community perceptions regarding FGR benefits in urban and rural areas conducted and detailed classification of FGR products and values developed	**Recommended Action C.1.1.** *To conduct detailed field assessments and map typical/traditional or innovative FGR products and/or services, elaborated with local communities (including processed forest products, ecosystem services, ecotourism products etc.)*
		Recommended Action C.1.2. *To develop an interactive cadastre on the importance of FGR along with forest products and services provided by sustainable forests*
	Opportunity C.2. Concept of support for FGR conservation through supporting local communities to benefit of FGR multifunctional role created	**Recommended Action C.2.1.** *To advance cross-sectoral cooperation among forestry, water and soil management and rural development sectors including the development of integrated forest information system*
		Recommended Action C.2.2. *To develop guidelines for evaluating ecosystem services and guidelines about the vulnerability of FGR and the importance of its conservation and sustainable use for food security and poverty alleviation*
	Opportunity C.3. A long-term national breeding program for FGR developed and supported by the Government	**Recommended Action C.3.1.** *To foster inter-institutional cooperation in the area of FGR improvement and breeding and establish national network with the aim of programming breeding activities*
		Recommended Action C.3.2. *To develop multi-year breeding project proposals following objectives of the national breeding program and define possible financial sources*
	Opportunity C.4. FGR conservation and species-specific approach integrated to forest management	**Recommended Action C.4.1.** *To develop a methodology for data collecting and including the obtained data on genetic diversity in the process of forest management*
		Recommended Action C.4.2. *To develop species-specific technical guidelines targeted at practical forest managers and include this approach in forest management*

PRIORITY D: Policies, institutions and capacity building		
Challenge D To integrate FGR conservation in the strategic and legal framework of forestry, nature and environmental protection To implement a specific strategic and programming framework for FGR conservation To build and implement a policy of cross-sectoral dialogue for the successful implementation of FGR conservation activities To strengthen the capacities of public, private and civil sector in the area of FGR conservation	**Opportunity D.1.** Existing strategic framework in the forestry, nature and environmental protection, with an emphasis on the *holistic approach* to forest management developed	**Recommended Action D.1.1.** *To establish an ad hoc expert group for strategic planning, programming and monitoring in the area of FGR conservation*
		Recommended Action D.1.2. *To revise the existing Forestry Development Strategy of the Republic of Serbia (2006) and other relevant strategic documents and better integrate FGR conservation goals defined by the ad hoc expert group*
	Opportunity D.2. The existing forest management legal framework harmonized with the expected intensity of changes in environmental conditions and climate change	**Recommended Action D.2.1.** *To assess the existing legal and by-law framework related to reproductive material of FGR and its transfer and to compare it with research results on expected intensity of environmental and climate changes*
		Recommended Action D.2.2. *To adopt and implement revised legal and by-law framework including defined measures of assisted migration of genetic material and adaptation capacity improvement*
	Opportunity D.3. The NPFGR implemented through a national network of continuous cross-sectoral cooperation and led by the *ad hoc* FGR expert group	**Recommended Action D.3.1.** *To develop a national platform for cooperation based on a memorandum of understanding*
		Recommended Action D.3.2. *To foster adoption and implementation of the NPFGR and to redefine time framework for defined objectives, priorities and measures*
	Opportunity D.4. Capacities of all relevant entities and stakeholders related to FGR conservation and breeding are well developed and sufficient and there is a high level of public awareness	**Recommended Action D.4.1.** *To develop a long-term training program and educational materials for all relevant stakeholders in order to strengthen the capacity to harmonize forest management with goals of FGR conservation and to improve the promotion of the concept of FGR conservation*
		Recommended Action D.4.2 *To provide equipment and improve the skills of employees in public enterprises for the application of modern software packages for modeling ecosystem processes in relation to rnvitonmental and climate changes*

REFERENCES

Aleksić, P., Jančić, G., Vasić, V. (2013). Impact of climate changes on silviculture. Ecologica No. 71: 416-420 (*in Serbian, with abstract in English*)

Aleksić P., Maksimović Z. (2015). Production of forest reproductive material for the purpose of establishment of new forests and reforestation in PE „Srbijašume" Belgrade. Šumarstvo, No. 1-2: 151-166 (*in Serbian, with abstract and summary in English*)

Banković S, Medarević M, Pantić D, Petrović N, Šljukić B, Obradović S (2009): The growing stock of the Republic of Serbia - state and problems. Bulletin of the Faculty of Forestry - University of Belgrade, No. 100: 7-30 (*in Serbian, with abstract and summary in English*)

Čortan D., Šijačić-Nikolić M., Knežević R. (2014). Variability of morphometric leaf characteristics of Black poplar from the area of Vojvodina. Bulletin of the Faculty of Forestry - University of Belgrade, No. 109: 63-72 (*in Serbian, with abstract and summary in English*)

Čortan D. (2015). Genetic diversity of black poplar (*Populus nigra* L.) natural populations in the area of Vojvodina assessed by genetic markers. Doctoral dissertation, University of Belgrade - Faculty of Forestry, Belgrade (213) (*in Serbian, with summary in English*)

Čortan D., Vilotić D., Šijačić-Nikolić M. (2015). Inter and intra-population variation of leaf stomatal traits of *Populus nigra* L. in Vojvodina, Northern Serbia. The Final European Forest Research and Innovation Area - EUFORINNO conference, Rogla, Slovenia, 31st August-4th September 2015, Book of Abstracts: 6

Čortan D., Tubić B., Šijačić-Nikolić M., Borota D. (2015a). Variability of Black Poplar (*Populus nigra* L.) Leaf Morphology in Vojvodina, Serbia. Šumarski list, Vol. 139, No. 5-6: 245-252

Čortan D., Schroeder H., Šijačić-Nikolić M., Wehenkel C., Fladung M. (2016). Genetic structure of remnant black poplar (*Populus nigra L.*) populations along biggest rivers in Serbia assessed by SSR markers. Silvae Genetica 65 (1): 12-19

Čortan D., Vilotić D., Šijačić-Nikolić M., Miljković D. (2017). Leaf stomatal traits variation within and among black poplar native populations in Serbia. Bosque 38 (2): 337-345

Čortan D., Nonić M., Šijačić-Nikolić M. (2019). Phenotypic plasticity of European beech from international provenance trial in Serbia. In: Šijačić-Nikolić M., Milovanović J., Nonić M. (eds.): Forests of Southeast Europe Under a Changing Climate: Conservation of Genetic Resources. Springer Nature Switzerland AG, Cham: 333-351

Devetaković J., Stanković D., Ivetić V., Šijačić-Nikolić M., Maksimović Z. (2016). Potential of different European white elm (*Ulmus laevis* Pall.) genotypes for phytoextraction of heavy metals. Fresenius Environmental Bulletin 10 (25): 4318-4323

Devetaković J. (2017). Genetic potential of European white elm (*Ulmus laevis* Pall.) for production of selected seedling material. Doctoral dissertation, University of Belgrade - Faculty of forestry (244) (*in Serbian, with summary in English*)

Djordjević-Milošević S. (2019). Socio-economic perspectives of sustainable forest management and local development in Serbia. Report for the project GCP/SRB/002/GEF: Contribution of sustainable forest management to low emission and resilient development in Serbia (FSP). UN FAO, p. 138

Isajev V. (1987). Serbian spruce (*Picea omorika* /Panc. Purkyne/) breeding on the genetic-selection basis. Doctoral dissertation, University of Belgrade - Faculty of Forestry, Belgrade (321) (*in Serbian, with summary in English*)

Isajev V., Šijačić M., Vilotić D. (1994). Variability of macroscopic and microscopic characteristics of two-year-old seedlings of 26 half-sib families of Balkan maple (*Acer heldreichii* Orph.). Šumarstvo No. 3-4: 21-28 ((*in Serbian, with abstract and summary in English*)

Isajev V., Šijačić-Nikolić M., Mataruga M. (1999). Conservation, tasting and utilisation of tree species gene pool in specialised plantations. Proceedings of the 4th International Conference on the Development of Wood Science, Wood Technology and Forestry, Missenden Abbey, 225-235

Isajev V., Šijačić-Nikolić M. (2001). *Ex situ* pool conservation of Serbian spruce (*Picea omorika* /Panč./ Purkyne) and Balkan maple (*Acer heldreichii* Orph.) in seedling seed orchard, 1st International Symposium Food in the 21st Century, November 17-19, Subotica, Yugoslavia, Book of Abstracts: 142

Isajev V., Šijačić-Nikolić M. (2003). Practical textbook of genetics and plant breeding. Faculty of Forestry - University of Belgrade, Faculty of Forestry - University of Banja Luka, Belgrade - Banja Luka (*in Serbian*)

Isajev V, Šijačić-Nikolić M (2003a): Conservation of conifer tree species in Serbia. International Conference The Question of Conversion of Coniferous Forest, September 22-October 02, 2003, Freiburg im Breisgau, Germany, Book of Abstracts: 44

Isajev V., Vukin M., Ivetić V. (2004). Introduction of conifers in coppice beech forests in Serbia. Šumarstvo, No. 3: 63-75 (*in Serbian, with abstract and summary in English*)

Ivetić, V. (2009). Delineation of beech provenance regions in Serbia by spatial analysis of genetic diversity. Doctoral dissertation, University of Belgrade - Faculty of Forestry, Belgrade (*in Serbian, with summary in English*)

Ivetić V. (2015). Reforestation in Serbia: Success or failure? In: Ivetić V., Stanković D. (eds.) Proceedings: International conference Reforestation Challenges. 03-06 June 2015, Belgrade, Serbia. Reforesta: 1-12

Ivetić V., Devetaković, J., Davorija Z., Šijačić-Nikolić M. (2015). Intra- and inter-provenance variability of *Ostrya carpinifolia* Scop. seedlings. Bulletin of the Faculty of Forestry - University of Belgrade, No. 112: 33-42 (*in Serbian, with abstract and summary in English*)

Ivetić V., Aleksić J.M. (2016). Response of rare and endangered species *Picea omorika* to climate change - The need for speed. Reforesta 2: 81-99

Ivetić V., Devetaković J., Nonić M., Stanković D., Šijačić-Nikolić M. (2016). *Genetic diversity and forest reproductive material - from seed source selection to planting*. iForest Vol. 9: 801-812

Ivetić V. (2019). Revision of beech provenance regions in Serbia. Project report, Ministry of agriculture, forestry and water management - Directorate of forests

Jokanović D., Vilotić D., Nikolić V., Šijačić-Nikolić M., Stanković D. (2018). Morpho-anatomical petiole characteristics of beech in natural populations in Serbia. Fresenius Environmental Bulletin, Vol. 27, No. 9: 6087-6092

Jokanović D., Jokanović-Nikolić V., Petrović J., Ćirković-Mitrović T. (2019). Morpho-anatomical features of the beech petiole from different provenances in Serbia. Šumarstvo, No. 1-2: 143-153 (*in Serbian, with abstract and summary in English*)

Kerkez I., Popović V., Šijačić-Nikolić M. (2015). Variability of morphometric characteristics of leaves of different Wild cherry (*Prunus avium* L.) test trees in Belgrade. First International Forestry Students Conference, Belgrade, Serbia, 1-5 September, Book of Abstracts: 20

Kerkez I. (2016). Genetic variability of Wild cherry (*Prunus avium* L.) in Serbia. Master thesis, University of Belgrade - Faculty of Forestry, Belgrade (*in Serbian, with summary in English*)

Kerkez I., Popović V. (2016). Population variability of Wild cherry (*Prunus avium* L.) in Serbia according to the leaf morphology. Šumarski list, No. 7-8: 347-355

Lalović V. (2016). Basic elements of conservation of forest genetic resources and their institutional-legal aspects. Master thesis, University of Belgrade - Faculty of Forestry, Belgrade (78) (*in Serbian, with summary in English*)

Lavadinović V., Koprivica M. (1996). Development of young Douglas-fir (*Pseudotsuga taxifolia* Britt.) stands of different provenances on beech sites in Serbia. Proceedings of IUFRO Conference Modelling Regeneration Success and Early Growth of Forest Stands, Copenhagen, Denmark: 390-400

Lavadinović V., Koprivica M. (1997). Dependence of Douglas-fir height increment on geographic characteristics of provenances in East Serbia. The First Balkan Botanical Congress. Thessaloniki, Greece, Book of Abstracts: 160

Lučić A., Nikolić A., Mladenović-Drinić S., Isajev V., Lavadinović V. (2008). Genetic characterization of genotypes of Austrian pine (*Pinus nigra* Arnold) populations using protein markers. Genetics, Vol. 40, No. 2:145-157

Lučić A., Isajev V., Mladenović-Drinić S., Rakonjac Lj. (2010). Determination of genetic diversity of Scots pine (*Pinus sylvestris* L.) and Austrian pine (*Pinus nigra* Arn.) in Serbia using protein markers. Bulletin of Faculty of Forestry - University of Banja Luka, No. 12: 10-19 (*in Serbian, with abstract summary in English*)

Lučić A. (2011). Establishment of Scots pine forests (*Pinus sylvestris* L.) in Serbia on ecological and genetic basis. Doctoral dissertation, University of Belgrade - Faculty of Forestry, Belgrade (*in Serbian, with summary in English*)

Lučić A., Isajev V., Rakonjac Lj., Živadinović V. (2011). Variability of morphometric characteristics of Scots pine cones (*Pinus sylvestris* L.) in Serbia. Šumarstvo, No. 1-2: 83-94 (*in Serbian, with abstract and summary in English*)

Lučić A., Isajev V., Cvetićanin R., Rakonjac Lj., Novaković M., Nikolić A., Mladenović-Drinić S. (2011a). Interpopulation genetic-ecological variation of Scots pine (*Pinus sylvestris* L.) in Serbia, Genetika, No. 43: 1-18

Lučić A., Isajev V., Rakonjac Lj., Ristić D., Kostadinović M., Babić V., Nikolić A. (2011b). Genetic divergence of Scots pine (*Pinus sylvestris* L.) populations in Serbia revealed by RAPD, Archives of Biological Sciences 63: 371-380

Maksimović Z., Šijačić-Nikolić M. (2013). Morphometric characteristics of black poplar (*Populus nigra* L.) leaves in the area of Great War Island. Bulletin of the Faculty of Forestry - University of Belgrade, No. 108: 93-108 (*in Serbian, with abstract and summary in English*)

Maksimović Z., Čortan D., Ivetić V., Mladenović-Drinić S., Šijačić-Nikolić M. (2014). Genetic structure of black poplar (*Populus nigra* L.) populations in the area of Great War Island. Genetika, Vol. 46, No.3: 963-973

Maksimović Z. (2015). Conservation and sustainable utilization of black poplar (*Populus nigra* L.) gene pool in the area of Great War Island. Doctoral dissertation, University of Belgrade - Faculty of Forestry, Belgrade (213) (*in Serbian, with summary in English*)

Medarević M. (2005). Forest types in the National Park „Djerdap". University of Belgrade - Faculty of Forestry, Ministry of Science and Environmental Protection of the Republic of Serbia and National Park „Djerdap", Belgrade (158) (*in Serbian*)

Medarević M., Šljukić B., Obradović S. (2014). Sustainable Forest Management Planning in Serbia. Bulletin of the Faculty of Forestry - University of Belgrade, special issue: 9-24 (*in Serbian, with abstract and summary in English*)

Milovanović J., Šijačić-Nikolić M., Vilotić D., Ivetić V. (2004). Morpho-anatomical characteristics of Serbian spruce needles from different phenogrups. Acta herbologica, Vol. 14, No. 1: 41-50

Milovanović J. (2007). Investigation of Serbian spruce (*Picea omorika* /Panč./ Purkyne) intraspecific variability applying genetic markers. Magistral thesis, University of Belgrade - Faculty of Forestry, Belgrade (86) (*in Serbian, with summary in English*)

Milovanović J. (2009). Ecological-genetic basis of variability of Sessile oak (*Quercus petreae* agg. Ehrendorfer 1967.) in Serbia. Doctoral dissertation, Singidunum University - Faculty of applied ecology „Futura", Belgrade (*in Serbian, with summary in English*)

Milovanović J., Šijačić-Nikolić M. (2010). Characterization of Serbian spruce variability applying isoenzyme markers. Biotechnology & Biotechnological Equipment, Vol. 24 (1): 1600-1605

Milovanović J., Šijačić-Nikolić M., Nonić M., Radojević U. (2012). Forest genetic resources in international initiatives and legislation. Šumarstvo, No. 3-4, Beograd: 111-131 (*in Serbian, with abstract and summary in English*)

Nonić D. (2015). Organisation and business administration in forestry - book, Electronic resource, University of Belgrade - Faculty of forestry, Belgrade (398)

Nonić M., Heinze B., Mengl M., Devetaković J., Slunsky R. (2015). Intra-population genetic diversity of beech in northeast Serbia assessed by microsatellite markers. In: Ivetić, V., Stanković, D. (eds.) Proceedings: International Conference Reforestation Challenges. 03-06 June 2015, Belgrade, Serbia, Reforesta: 266-275

Nonić M. (2016). Improving mass production of ornamental beech cultivars by grafting. Doctoral dissertation, University of Belgrade - Faculty of Forestry, Belgrade (281) (*in Serbian, with summary in English*)

Nonić M., Nedeljković J., Lalović V., Šijačić-Nikolić M., Nonić D. (2017a). Legal framework and stakeholders' attitudes toward the conservation of forest genetic resources. IUFRO 125th Anniversary Congress, 18-22 September 2017, Freiburg, Germany, Book of abstracts: 484

Nonić, M., Nedeljković, J., Nonić, D. (2017b). Strategic and legal framework of forest genetic resources conservation in Serbia. Selekcija i semenarstvo, Vol. XXIII (2017), No. 1: 11-26

Nonić M., Skočajić D., Šijačić Nikolić M., Grbić M. (2017c). Variability of quantitative and qualitative characteristics of Fagus sylvatica 'Purpurea' clones produced by grafting. Not Bot Horti Agrobo, 2017, 45(2): 400-407

Nonić M., Čortan D., Batalo T., Šijačić-Nikolić M. (2019). Comparative analysis of morphological characteristics of beech leaves from the European provenance trial. Bulletin of the Faculty of Forestry - University of Belgrade, No. 119: 145-174

Nonić M., Nedeljković J., Nonić D., Milovanović J., Šijačić-Nikolić M. (2019a). Regulatory framework for conservation and sustainable utilization of forest genetic resources in Serbia. In: Šijačić-Nikolić M., Milovanović J., Nonić M. (eds.): Forests of Southeast Europe Under a Changing Climate: Conservation of Genetic Resources. Springer Nature Switzerland AG, Cham: 87-104

Nonić D., Nedeljković J., Nonić M. (2019). Institutional framework for conservation of forest genetic resources in Serbia. In: Šijačić-Nikolić M., Milovanović J., Nonić M. (eds.): Forests of Southeast Europe under a Changing Climate Conservation of Genetic Resources. Springer Nature Switzerland AG, Cham 105-124

Orlović S., Klašnja B., Galić Z., Pilipović A. (2002). Conservation of Pedunculate oak (*Quercus robur* L.) in Yugoslavia. In: Kremer A., Savolainen O., Turok J. (eds.): Proceedings of DYGEN Conference: Dynamics and Conservation of Genetic Diversity in Forest Ecosystems, Strasbourg, France: 210

Popović V. (2013). Assessment of Bald cypress (*Taxodium distichum* (L.) Rich.) genetic potential in seed stand near Backa Palanka. Doctoral dissertation, University of Belgrade - Faculty of Forestry, Belgrade (205) (*in Serbian, with summary in English*)

Popović V., Lučić A., Rakonjac L. (2017). State of the forest genetic resources in Serbia and the overview of the activities for their conservation. Selekcija i semenarstvo, 23(2): 1-13

Popović V., Lučić A., Rakonjac L. (2019). The Establishment of a clonal seed orchard of wild cherry (*Prunus avium* L.) in the area of Western Serbia. Šumarstvo, No. 1-2: 163-178 (*in Serbian, with abstract and summary in English*)

Stojnić S., Orlović S., Pilipović A., Kebert M., Šijačić-Nikolić M., Vilotić D. (2010). Variability of physiological parameters of different European beech provenances in international provenance trials in Serbia, Acta Silv. Hung., Vol. 6, 135-142.

Stojnić S., Orlović S., Galić Z., Vasić V., Vilotić D., Knežević M., Šijačić-Nikolić M. (2012). Environmental characteristics in the European beech provenance trials at Fruška Gora Mountain and Debeli Lug. Topola, No. 189-190: 145-162 (*in Serbian*)

Stojnić S. (2013). Variability of anatomical, physiological and morphological traits of different European beech provenances in Serbia. Doctoral dissertation, University of Belgrade - Faculty of Forestry, Belgrade (323) (*in Serbian, with summary in English*)

Šijačić-Nikolić M. (2000). Analysis of the genetic potential of Serbian spruce (*Picea omorika* (Panč.) Purkině) generative seed orchard by the controlled hybridization of half-sib lines. Doctoral dissertation, University of Belgrade - Faculty of Forestry, Belgrade (*in Serbian, with summary in English*)

Šijačić-Nikolić M. (2004). Polymorphism of protein markers of Serbian spruce seed obtained by cross-pollination and self-pollination. Bulletin of Faculty of Forestry - University of Banja Luka, No. 1: 63-72

Šijačić-Nikolić M., Isajev V. (2004). Assessment of heterotic effect in Serbian spruce hybrid combination. Genetika, Vol.36, No 3: 257-263

Šijačić-Nikolić M., Milovanović J. (2006). Inheritance Level of Leaf Reverse Color in *Acer pseudoplatanues* L. cv Atropurpureum. In: Fikret Isak (ed.) Proceedings of the IUFRO Divison 2 Join Conference: Low input breeding and genetic conservation of forest tree species, Antalya Turkey, 9-13 October: 184-187

Šijačić-Nikolić M., Isajev V., Ivetić V. (2006). National parks of Serbia - preservation and directed use of the forest tree gene pool. Scientific Conference: Management of Forest Ecosystems of National Parks and Other Protected Areas, Proceedings, Jahorina-NP Sutjeska, 5-8. July: 131-136

Šijačić-Nikolić M., Milovanović J. (2007). Conservation and directed utilization of forest genetic resources. Bulletin of the Faculty of Forestry - University of Belgrade, No. 95: 7-21 (*in Serbian, with abstract and summary in English*)

Šijačić-Nikolić M., Ivetić V., Knežević R., Milovanović J. (2007). The analysis of characteristics of seeds and seedlings of various provenances of beech. Acta herbologica, No. 1, Vol. 16: 15-27

Šijačić-Nikolić M., Milovanović J., Bobinac M. (2009). Sessile oak (*Quercus petraea* agg. Ehrendorfer 1967) Rare Haplotypes Appearance in Serbia. African Journal of Biotechnology, Vol. 8 (17), Academic Journals: 4117-4120

Šijačić-Nikolić M., Milovanović J., Knežević R. (2009a). Phenotypic stability of *Acer pseudoplatanus* cv Atropurpureum traits as a baseline of breeding process. Journal of Horticulture and Forestry, Vol. 1(3), Academic Journals: 38-42

Šijačić-Nikolić M., Milovanović J., Bobinac M., Savić-Pavićević D., Brajušković G., Diklić M. (2009b). Variability of the Chloroplast DNA of Sessile oak (*Quercus petraea* agg. Ehrendorfer 1967) in Serbia. Archives of Biological Sciences, Vol. 61, No. 3, Serbian Biological Society: 459-465

Šijačić-Nikolić M., Milovanović J. (2010). Conservation and directed utilization of forest genetic resources. Faculty of Forestry, University of Belgrade, Planeta Print, 200 p. (*in Serbian*)

Šijačić-Nikolić M., Ocokoljić M., Vilotić D., Milovanović J. (2011). The genetic potential of mother trees as a basis for Acer pseudoplatanus cv ′Atropurpureum′ plant production. Arch. Biol. Sci., No. 63 (1), Serbian Biological Society, Belgrade: 145-150

Šijačić-Nikolić M., Milovanović J., Nonić M., Knežević R., Babić V. (2012). Ecotypical characterization of genetic variation of beech provenances from South-Eastern Europe based on the morphometric characteristics of leaves. Bulletin of the Faculty of Forestry - University of Belgrade,106: 197-214

Šijačić-Nikolić M., Stanković D., Krstić B., Vilotić D., Ivetić V. (2012a). The potential of different lime tree (*Tilia* spp) genotypes for phytoextraction of heavy metals. Genetika, Vol 44, No 3: 537-548

Šijačić-Nikolić M., Milovanović J., Nonić M., Knežević R., Stanković D. (2013). Leaf morphometric characteristics variability of different beech provenances in juvenile development stage. Genetika, Vol. 45, No. 2: 369-380

Šijačić-Nikolić M., Milovanović J., Nonić M. (2014). Conservation of forest genetic resources. In: Ahuja M.R., Ramawat K.G. (eds.) „Biotechnology and Biodiversity" (Series: Sustainable development and biodiversity, Vol. 4). Springer International Publishing: 103-129

Šijačić-Nikolić M., Milovanović J., Nonić M. (2014a). Forest genetic resources in Serbia - state and recommendations for improvement in this area. Bulletin of the Faculty of Forestry – University of Belgrade (special issue): 51-70 (*in Serbian, with abstract and summary in English*)

Šijačić-Nikolić M, Vilotić D, Ivetić V, Milovanović J, Stanković D, Nonić M, Devetaković J, Jokanović D, Maksimović Z, Popović V, Rakonjac Lj, Lučić A, Orlović S, Galović V, Pilipović A, Stojnić S, Kovačević B, Trudić B (2016). National program for conservation and sustainable utilization of FGR of the Republic of Serbia for the period 2016-2025, Faculty of Forestry, Belgrade, Institute of forestry, Belgrade, Institute of lowland forestry and environment, Novi Sad (*in Serbian, with summary in English*)

Šijačić-Nikolić M., Nonić M., Lalović V., Milovanović J., Nedeljković J., Nonić D. (2017). Conservation of forest genetic resources: key stakeholders' attitudes in forestry and nature protection. Genetika 49(3): 875-890

Šijačić-Nikolić M., Sovilj Lj. (2017). Implementation of the Program for conservation and sustainable utilization of forest genetic resources in Republic of Serbia. Selekcija i semenarstvo, Vol. XXIII No. 2: 35-44 (*in Serbian, with abstract in English*)

Šijačić-Nikolić M., Milovanović J., Nonić M. (2019). *Forests of Southeast Europe under a changing climate: conservation of genetic resources*, Springer Nature Switzerland AG, Cham (486)

Tucović A., Isajev V. (1983). Some comparative observations in Serbian spruce cultures in different habitats in SR Serbia. Bulletin of the Faculty of Forestry - University of Belgrade, No. 60: 77-87 (*in Serbian, with abstract and summary in English*)

Tucović A., Isajev V. (1988). Generative Serbian spruce seed orchard in Godovik. Project report, Belgrade: 1-40

Tucović A., Isajev V. (1991). Metapopulation strategy of establishing generative seed orchards of trees. Proceedings: Past, present and future of Serbian forestry as a factor of development of Serbia, Belgrade: 313-323

Vasilijević M., Pokrajac S., Erg B. (eds.) (2019). Summary of national assessments of the state of nature conservation systems in South-Eastern Europe. Belgrade, Serbia: IUCN: ECARO, xiv+84pp

Vukin M., Isajev V. (2004). The study of influence of certain climatic factors on height increment of Austrian pine in the seed orchard on Jelova Gora. Bulletin of the Faculty of Forestry - University of Belgrade, No. 90: 91-107 (*in Serbian, with abstract and summary in English*)

INTERNET SOURCES

CEEPUS (2020): CEEPUS network. Available at: https://www.ceepus.info/public/network/network.aspx#nbb (accessed: 10/05/2020)

CONVERGES (2019). COST Action CONVERGES. Available at: https://converges.eu/ (accessed: 14/05/2020)
ECPGR (2020): ECPGR overview. Available at: https://www.ecpgr.cgiar.org/about/overview (accessed: 02/05/2020)

EFI (2020): EFI member countries. Available at: https://www.efi.int/about/member-countries (accessed: 03/05/2020)

EUFORGEN (2020): EUFORGEN member country - Serbia, Available at: http://www.euforgen.org/member-countries/serbia/ (accessed: 01/04/2020)

EUFORGEN (2020a): EUFORGEN Phase VI. Available at: http://www.euforgen.org/about-us/history/phase-vi-2020-2024/ (accessed: 01/04/2020)

EUFGIS (2020). EUFGIS Available at: http://www.eufgis.org/ (accessed: 01/04/2020)

FAO (2020). FAO - forestry. Available at: http://www.fao.org/forestry/49435/en/ (accessed: 12/03/2020)

FAO (2020a). FAO - county profiles. Available at: http://www.fao.org/countryprofiles/index/en/?iso3=SRB (accessed: 15/04/2020)

FB (2020a). Chair of Plant Ecology and Phythogeography, Faculty of Biology, Belgrade. Available at: https://www.bio.bg.ac.rs/01_katedra_osnovno.php?id_katedre=3 (accessed: 10/03/2020)

DOF (2016). Information about work scope, Ministry of agriculture and environmental protection-Forest Directorate, Belgrade, 52 pp.

DOF (2020). The Register of Selected Seed Facilities. Forest Directorate https://upravazasume.gov.rs/

FEU (2020). FOREST EUROPE. Available at: https://foresteurope.org/foresteurope/ (accessed: 28/03/2020)

FOF (2020). Faculty of Forestry - Chair of Seed Science, Nursery Production and Afforestation. Available at: http://www.sfb.bg.ac.rs/en/sections/forestry/chairs/the-chair-of-seed-science-nursery-practice-and-afforestation/ (accessed: 01/03/2020)

FOF (2020a). Faculty of Forestry - Center for monitoring and conservation of forest genetic resources. Available at: http://www.sfb.bg.ac.rs/en/sections/forestry/chairs/the-chair-of-seed-science-nursery-practice-and-afforestation/chair-centers/ (accessed: 01/03/2020)

FRA (2015). Country report Serbia. The Global Forest Resources Assessment http://www.fao.org/3/a-az330e.pdf

FB (2020). Biodiversity Information Center, Faculty of Biology, Belgrade. Available at: https://www.bio.bg.ac.rs/01_centar_osnovno.php?id_centra=14 (accessed: 10/03/2020)

G-BIKE (2020). COST Action G-BIKE. Available at: https://conferences.famnit.upr.si/event/18/overview (accessed: 20/04/2020)

GenRes Bridge (2019). GenRes Bridge project. Available at: http://www.genresbridge.eu/about-us/events/event/sharing-perspectives-workshop/ (accessed: 01/02/2020)

GIZ (2017). Natural Resource Management in Southeast Europe: Forest, Soil and Water. German Agency for International Cooperation - GIZ, Skopje, 2017

IBISS (2020). Department for Ecology, Institute for Biological Research „Siniša Stanković", Beograd, Available at: http://www.ibiss.bg.ac.rs/index.php/sr-yu/ekologija/odeljenje (accessed: 05/03/2020)

IF (2020). Department of Genetics, Plant Breeding, Seed and Nursery Production – Research, Institute of Forestry, Belgrade, Available at: http://www.forest.org.rs/?department-of-genetics-plant-breeding-seed-and-nursery-production (accessed: 20/03/2020)
IF (2020a). Forest Protection Division - Research, Institute of Forestry, Belgrade, Available at: http://www.forest.org.rs/?department-of-forest-protection (accessed: 20/03/2020)

ILFE (2020). Institute of lowland forestry and environment, Novi Sad. Available at: https://www.ilfe.org/en/research-fields-and-disciplines (accessed: 03/03/2020)

INC (2017). Information about the work scope. Institute for nature conservation of Serbia, Belgrade, 40 pp.

INC (2020). Institute for Nature Conservation of Serbia, http://www.zzps.rs/

INC (2020a). Institute for Nature Conservation of Serbia, http://www.zzps.rs/wp/osnovne-informacije/

INC (2020b). Institute for Nature Conservation of Serbia, http://www.zzps.rs/wp/np-fruska-gora/

INC (2020c). Institute for Nature Conservation of Serbia, http://www.zzps.rs/wp/np-kopaonik/

INC (2020d). Institute for Nature Conservation of Serbia, http://www.zzps.rs/wp/np-tra/

INC (2020e). Institute for Nature Conservation of Serbia, http://www.zzps.rs/wp/np-derdap/

INC (2020f). Institute for Nature Conservation of Serbia, http://www.zzps.rs/wp/np-sar-planina/

INCVP (2020). Institute for Nature Conservation of Voivodina Province. Available at: http://www.pzzp.rs/rs/en/about-us/item/213-activity-of-the-institute-for-nature-conservation-of-voivodina-province.html (accessed: 21/03/2020)

IMGG (2020). Laboratory for Molecular Biology of Plants, Institute of Molecular Genetics and Genetic Engineering, Belgrade. Available at: https://imgge.bg.ac.rs/index.php/en/research/research-areas/plant-mol-biology/lab-plant-biology (accessed: 20/03/2020)

IPA (2020). IPA fund. Available at: https://ec.europa.eu/neighbourhood-enlargement/instruments/overview_en (accessed: 01/02/2020)

IUCN (2020). IUCN members. Available at: https://www.iucn.org/about/members/iucn-members (accessed: 01/02/2020)

IUFRO (2020). The International Union of Forest Research Organizations, Available at: https://www.iufro.org/ (accessed: 23/04/2020)

IUFRO (2020a). IUFRO Unit 2.04.01 - Population, ecological and conservation genetics, Available at: https://www.iufro.org/science/divisions/division-2/20000/20400/20401/ (accessed: 23/04/2020)

IUFRO (2020b). IUFRO Unit 6.04.00 - Nature conservation and protected areas. Available at: https://www.iufro.org/science/divisions/division-6/60000/60400/ (accessed: 23/04/2020)

IUFRO (2020c). IUFRO Unit 8.02.00 - Forest biodiversity. Available at: https://www.iufro.org/science/divisions/division-8/80000/80200/ (accessed: 23/04/2020)

LCDS (2019). Proposal of Low carbon development strategy of the Republic of Serbia with Action Plan.
Available at: http://www.klimatskastrategija.eu/wp-content/uploads/2019/12/Low-Carbon-Development-Strategy-with-Action-plan_eng.pdf (accessed: 10/05/2020)
LIFEGENMON (2019). LIFEGENMON project - Seminar. Available at: https://ilfe.org/en/node/907/ (accessed: 30/03/2020)

MEP (2020). Sector for nature conservation and climate change, Ministry of environmental protection, Available at: http://www.ekologija.gov.rs/organizacija/sektori/sektor-za-zastitu-prirode-i-klimatske-promene/ (accessed: 31/03/2020)

NCS (2011). Proposal of the Nature Conservation Strategy of the Republic of Serbia for the period 2019 to 2025. Available at: http://www.misp-serbia.rs/wp-content/uploads/2010/05/EAS-Strategija-ENG-FINAL.pdf (accessed: 11/05/2020)

NFI (2008). National Forest Inventory of Republic of Serbia, Ministry of agriculture, forestry and water management of Republic of Serbia – Directorate of Forests. Available at: https://upravazasume.gov.rs/wp-content/uploads/2015/12/StanjeSumaRS.pdf

OECD (2014). Rules and Regulations of the OECD Forest Seed and Plant Scheme.

OG (2004). Law on Environmental Protection. „Official Gazette of the Republic of Serbia“, no. 135/2004, 36/2009, 72/2009, 43/2011, 14/2016

OG (2004a). Law on Forest Reproductive Material. „Official Gazette of the Republic of Serbia“, no. 135/2004, 8/2005, 41/2009

OG (2005). Decree on putting under control the use and trade of wild flora and fauna. „Official Gazette of the Republic of Serbia“, no. 31/2005, 45/2005, 22/2007, 38/2008, 9/2010, and 69 /2011

OG (2005a). Regulation on the recognition of starting material and control of production of reproductive material of forest trees. „Official Gazette of the Republic of Serbia“, no. 76/05, 105/05, 83/09

OG (2006). Forestry development strategy of the Republic of Serbia. „Official Gazette of the Republic of Serbia“, no. 59/2006

OG (2008). National sustainable development strategy. „Official Gazette of the Republic of Serbia“, no. 57/2008

OG (2009). Law on Agriculture and Rural Development „Official Gazette of the Republic of Serbia“, no. 41/2009, 10/2013 and 101/2016

OG (2009a). Law on Genetically Modified Organisms. „Official Gazette of the Republic of Serbia“, no. 41/2009

OG (2009b). Law on Nature Protection. „Official Gazette of the Republic of Serbia“, no. 36/2009, 88/2010, 91/2010, 14/2016

OG (2009c). Regulation on the quality of reproductive material of poplar and willow. „Official Gazette of the Republic of Serbia“, no. 76/2009

OG (2009d). Regulation on small quantities of forest seed and forest seedlings. „Official Gazette of the Republic of Serbia“, no. 76/2009

OG (2009e). Rulebook on the transboundary movement and trade in protected species. „Official Gazette of the Republic of Serbia“, no. 99/2009 from 1.12.2009

OG (2010). Law on Forests. „Official Gazette of the Republic of Serbia“, no. 30/2010; 93/2012, 89/2015 and 95/2018

OG (2010a). National program on environmental protection. „Official Gazette of the Republic of Serbia“, no. 12/2010

OG (2010b). Rulebook on conditions for establishing a gene bank of wild plants, animals and fungi, the manner of work of gene bank, manner of handling biological material, content of applications and documentation to be submitted with the application for the issuance of permit for establishing a gene bank. „Official Gazette of the Republic of Serbia“, no. 65/10

OG (2010c). Rulebook on declaration and protection of strictly protected and protected wild species of plants, animals and fungi. „Official Gazette of the Republic of Serbia“, no. 5/10, 47/11, 32/16

OG (2011). Biodiversity strategy of the Republic of Serbia for the period 2011-2018. „Official Gazette of the Republic of Serbia“, no. 13/2011

OG (2011a). Regulation on balance of forest reproductive material. „Official Gazette of the Republic of Serbia“, no. 46/11

OG (2012). National strategy for sustainable use of natural goods and resources. „Official Gazette of the Republic of Serbia“, no. 33/2012

OG (2014). Strategy for Agriculture and Rural Development of the Republic of Serbia for the period 2014-2024. „Official Gazette of the Republic of Serbia“, no. 85/2014

OG (2015). Law on National Parks. „Official Gazette of the Republic of Serbia“, no. 84/15, 95/18

OG (2018). Law on Ratification of the Nagoya Protocol. „Official Gazette of the Republic of Serbia“, no. 12/2018

REC (2020). REC Serbia. Available at: http://serbia.rec.org/index-eng.php (accessed: 30/03/2020)

SAWF (2020). The Provincial Secretariat for agriculture, water management and forestry. Available at: http://www.vojvodina.gov.rs/en/provincial-secretariat-agriculture-water-management-and-forestry (accessed: 10/03/2020)

SORS (2019). Statistical Office of the Republic of Serbia, press release No. 126, 2019

SPRS (2010). The Spatial Plan of the Republic of Serbia, „Official Gazette of the Republic of Serbia", no. 88/10

SŠ (2020): PE „Srbijašume". Available at: https://srbijasume.rs/en/rasadnici/proizvodnja-sadnog-materijala/rasadnici-sumskih-sadnica/ (accessed: 02/05/2020)

SUPEP (2020). The Provincial Secretariat for urban planning and environmental protection. Available at: http://www.vojvodina.gov.rs/en/provincial-secretariat-urban-planning-and-environmental-protection (accessed: 10/03/2020)

SYRS (2018). Statistical Yearbook of the Republic of Serbia, 2018

UNDP (2020). UNDP Serbia. Available at: https://www.rs.undp.org/content/serbia/en/home/about-us.html (accessed: 03/05/2020)

VŠ (2020). PE „Vojvodinašume". Available at: http://www.vojvodinasume.rs/zastita-zivotne-sredine/ (accessed: 01/03/2020)

WWF ADRIA (2020). WWF Adria - Serbia. Available at: https://www.wwfadria.org/sr/sta_radimo/priroda/ (accessed: 03/05/2020)

ANNEXES

Annex 1.1. Trees and other woody species important for food security and/or poverty reduction in Serbia

Species		Use for food security	Use for poverty reduction
Scientific name	**Nature (N) or Exotic (E)**		
Abies alba Mill.	N		+
Aesculus hipocastanum L.	N		+
Alnus glutinosa Gaerttn.	N		+
Alnus incana Moench	N		+
Betula pendula Roth	N	+	+
Castanea sativa Mill.	N	+	+
Corylus colurna L.	N		+
Corylus avelana L.	N	+	+
Cornus mas L.	N	+	+
Crataegus aria L.	N	+	+
Crataegus monogyina Jacq.	N	+	+
Crataegus oxycantha L.	N	+	+
Crataegus pentagyna Waldst.and Kit.ex Wild	N	+	+
Fagus silvatica ssp. moesiaca (Domin, Maly)	N	+	+
Fraxinus excelsior L.	N		+
Fraxinus ornus L.	N		+
Juglans regia L.	E	+	+
Juniperus communis L.	N	+	+
Juniperus communis L. *ssp. nana Syme*	N	+	+
Malus silvestris Mill.	N	+	+
Malus pumila Mill.	N	+	+
Morus alba L.	E	+	+
Morus nigra L.	E	+	+
Picea abies (L.) H. Karst.	N	+	
Pinus nigra Arnold	N		+
Pinus silvestris L.	N		+
Populus nigra L.	N		+
Prunus avium L.	N	+	+
Prunus carasifera Ehrh.	N	+	+
Prunus fruticosa L.	N	+	+
Prunus insititia L.	N	+	
Prunus spinosa L.	N	+	+
Pyrus amygdaliformis Will.	N	+	+
Pyrus communis L.	N	+	+
Pyrus elaeagrifolia Pall.	N	+	
Quercus petrea (Matt.) Liebl.	N		+
Quercus robur L.	N		+
Ribes alpinum L.	N	+	
Ribes multiflorum Kit.	N	+	
Ribes nigrum L.	N	+	
Ribes petraeum Wulf.	N	+	
Robinia pseudoacacia L.	E	+	+
Rosa canina L.	N	+	+
Rubus fruticosus L.	N	+	+
Rubus idaeus L.	N	+	+
Salix alba L.	N	+	+
Salix purpurea L.	N		+
Tilia cordata Miller	N	+	
Sambucus nigra L.	N	+	+
Sorbus domestica L.	N	+	
Sorbus torminalis L. Crantz.	N	+	
Tilia tomentosa Moench	N	+	+
Vaccinium myrtillus L.	N	+	+
Vaccinium uliginosum L.	N	+	+
Vaccinium vitis-idea L.	N	+	+
Viscum album L.	N	+	+

Annex 3.1. Species represented in shrubs and bushes of other wooded lands (OWLs)

Species	
Acer monsepssulanum	*Myricaria germanica*
Alnus viridis	*Ostrya carpinifolia*
Amelanhier ovalis	*Paliurus spina-christii*
Amorpha fruticosa	*Picea abies subalpina*
Amygdalus nana	*Pinus mugo*
Arctostaphylos spp.	*Prunus fruticosa*
Astragalus angusiifolius	*Prunus mahaleb*
Bruckenthalia spiculifolia	*Prunus spinosa*
Buxus sempervirens	*Rhamnus fallax*
Calluna vulgaris	*Rhamnus rupestris*
Carpinus orientalis	*Rhododendron kotschyi*
Chamaecytisus spp.	*Rosa spinossisima*
Corylus avellana	*Rosa spp.*
Cotinus coggygria	*Salix appendiculata*
Cotoneaster spp.	*Salix caprea*
Crataegus spp.	*Salix cinerea*
Cytisus scoparius	*Salix eleagnos*
Dryas octopetala	*Salix herbacea*
Empetrum nigrum	*Salix pentandra*
Erica herbacea	*Salix purpurea*
Ericaceae	*Salix reticulata*
Forsythia europaea	*Salix retusa*
Frangula rupestris	*Salix rosmarinifolia*
Fraxinus ornus	*Salix silesiaca*
Genista radiata	*Salix triandra*
Genista spp.	*Salix waldsteiniana*
Juniperus communis	*Sambucus racemosa*
Juniperus excelsa	*Sorbus mougeotii*
Juniperus nana	*Staphyllea pinnata*
Juniperus oxycedrus	*Syringa vulgaris*
Ligustrum vulgare	*Tamarix spp.*
Loiseleuria procumbens	*Vaccinium myrtillus*
Lonicera alpigena	*Vaccinium uliginosum*
Myricaria ernesti-mayeri	

Annex 4.1. State of the Serbian forest fund by tree species, 2007

Species	Number of trees		Volume		Volume increase		Piv
	Kom.	%	m^3	%	m^3	%	
HARDWOOD SPECIES							
Fagus sp.	436.581.955	20,6	146.850.828,0	40,5	2.781.812,0	30,6	1,9
Carpinus betulus L.	254.122.298	12,0	15.157.240,0	4,2	334.572,0	3,7	2,2
Quercus cerris L.	234.088.620	11,1	46.980.446,0	13,0	1.034.876,0	11,4	2,2
Robinia pseudoacacia L.	218.845.449	10,3	11.243.944,0	3,1	516.857,0	5,7	4,6
Quercus farnetto Ten.	153.215.803	7,2	20.986.465,0	5,8	518.767,0	5,7	2,5
Quercus petraea (Matt.) Liebl.	129.994.747	6,1	21.542.890,0	5,9	553.735,0	6,1	2,6
Fraxinus ornus L.	103.786.655	4,9	3.505.758,0	1,0	102.158,0	1,1	2,9
Carpinus orientalis Mill.	88.444.273	4,2	1.717.529,0	0,5	55.073,0	0,6	3,2
Acer campestre L.	47.615.184	2,3	3.181.303,0	0,9	73.152,0	0,8	2,3
Other hardwood species	45.576.148	2,2	2.942.000,0	0,8	90.189,0	1,0	3,1
Populus tremula L.	22.521.210	1,1	2.358.305,0	0,7	92.646,0	1,0	3,9
Ostrya carpinifolia Scop.	21.951.640	1,0	1.480.694,0	0,4	33.966,0	0,4	2,3
Ulmus minor Miller.	18.665.149	0,9	1.097.943,0	0,3	43.101,0	0,5	3,9
Tilia platyphyllos Scop.	16.763.340	0,8	3.535.861,0	1,0	70.651,0	0,8	2,0
Fraxinua angustifolia Vahl.	15.416.856	0,7	5.792.311,0	1,6	153.519,0	1,7	2,7
Prunus avium L.	12.660.326	0,6	1.292.269,0	0,4	32.386,0	0,4	2,5
Quercus pubescens Willd.	12.128.717	0,6	956.167,0	0,3	28.564,0	0,3	3,0
Betula sp.	11.642.500	0,6	874.774,0	0,2	33.210,0	0,4	3,8
Quercus robur L.	10.996.463	0,5	9.242.373,0	2,5	157.886,0	1,7	1,7
Acer sp.	10.862.874	0,5	1.433.355,0	0,4	38.737,0	0,4	2,7
Tilia cordata Mill.	7.525.534	0,4	944.874,0	0,3	20.156,0	0,2	2,1
Salix sp.	6.662.601	0,3	1.912.086,0	0,5	42.819,0	0,5	2,2
Populus x *euroamericana* (Dode) Guinier	6.489.959	0,3	6.137.862,0	1,7	338.272,0	3,7	5,5
Fraxinus americana L.	6.482.204	0,3	157.576,0	0,0	4.453,0	0,0	2,8
Fraxinus excelsior L.	5.982.538	0,3	767.274,0	0,2	21.399,0	0,2	2,8
Tilia tomentosa Moench.	5.958.221	0,3	1.779.096,0	0,5	32.162,0	0,4	1,8
Alnus sp.	5.079.787	0,2	763.678,0	0,2	22.720,0	0,3	3,0
Junglans regia L.	2.546.708	0,1	314.440,0	0,1	10.032,0	0,1	3,2
Corylus colurna L.	2.523.181	0,1	207.391,0	0,1	6.521,0	0,1	3,1
Populus alba L.	1.987.969	0,1	607.150,0	0,2	24.716,0	0,3	4,1
Sorbus torminalis (L.) Cr.	1.983.424	0,1	110.265,0	0,0	2.480,0	0,0	2,2
Acer platanoides L.	1.693.850	0,1	417.960,0	0,1	9.910,0	0,1	2,4
Populus nigra L.	1.457.553	0,1	1.017.364,0	0,3	42.236,0	0,5	4,2
Acer negundo L.	1.090.309	0,1	92.276,0	0,0	2.693,0	0,0	2,9
Celtis australis L.	940.783	0,0	55.588,0	0,0	1.694,0	0,0	3,0
Ulmus montana With.	898.618	0,0	187.079,0	0,1	4.173,0	0,0	2,2
Acer heldreichii Orph.	816.528	0,0	95.318,0	0,0	3.179,0	0,0	3,3
Ulmus effusa Willd.	783.258	0,0	32.297,0	0,0	1.548,0	0,0	4,8
Junglans nigra L.	336.701	0,0	154.850,0	0,0	4.169,0	0,0	2,7
Sorbus aucuparia L.	5.659	0,0	3.377,0	0,0	36,0	0,0	1,1
Total hardwood species	**1.927.125.592**	**91,1**	**317.930.256,0**	**87,7**	**7.341.225,0**	**80,9**	**2,3**
CONIFEROUS SPECIES							
Pinus nigra Arn.	84.964.004	4,0	12.659.027,0	3,5	714.858,0	7,9	5,6
Pice abies Karst.	57.532.098	2,7	18.810.547,0	5,2	605.246,0	6,7	3,2
Pinus silvestris L.	26.177.724	1,2	3.775.430,0	1,0	176.870,0	1,9	4,7
Abies alba Mill.	13.797.216	0,7	8.304.924,0	2,3	199.851,0	2,2	2,4
Pinus strobus L.	2.079.983	0,1	355.416,0	0,1	18.708,0	0,2	5,3
Pseudotsuga menziesii (Mirb.) Fraco	1.641.064	0,1	511.151,0	0,1	16.141,0	0,2	3,2
Larix decidua Mill.	995.956	0,0	107.760,0	0,0	5.167,0	0,1	4,8
Other conifers	309.482	0,0	30.516,0	0,0	1.620,0	0,0	5,3
Taxus baccata L.	12.732	0,0	2.395,0	0,0	83,0	0,0	3,5
Total conifers	**187.510.260**	**8,9**	**44.557.162,0**	**12,3**	**1.738.547,0**	**19,1**	**3,9**
TOTAL							
Total	**2.114.635.852**	**100,0**	**362.487.418,0**	**100,0**	**9.079.772,0**	**100,0**	**2,5**

Annex 4.2. Exotic (introduced) tree species in the Republic of Serbia

Species	Status	Sites	Note (original reference)
Foreign invasive, potentially invasive and subspontaneously present species			
Acer negundo L.	naturalized	natural and culture	It occurs in forest communities along rivers and lakes [1,4,5]
Ailanthus altissima (Miller) Swingle	naturalized	natural and culture	Very widespread[1,4,5]
Broussonetia papyrifera (L.) Vent.	naturalized	artificial, rarely natural	Planted in individual localities; spread to surrounding habitats[1,4,5]
Celtis occidentialis L.	naturalized	artificial and natural	Except in alleys and parks, the species has formed populations in lowland forests along rivers and canals[1,4,5]
Elaeagnus angustifolia L.	naturalized	artificial, rarely natural	Escaped either from parks or from hedges around farmland, rarely in nature[1,5]
Fraxinus americana L.	naturalized	forest culture, artificial, natural	The species has been planted in forest cultures, alleys or as single trees and has spread to natural habitats. Very rare in our country (Jovanović, 2007)[1,4,5]
Fraxinus pennsylvanica Marshall	naturalized	forest culture, artificial, natural	Primarily river alluviums, sporadically, without stable populations. Cultures of this ash tree are often established in Serbia, for example, in Lipovica Forest there is a culture established in 1960 on 2 ha in the habitat of the Hungarian oak and Turkey oak (*Quercetum frainetto-cerris*)[2]. This species is often mistakenly considered as American ash (*Fraxinus americana* L.), which is very rare in our country (Jovanović, 2007)[1,2,4,5]
Gleditsia triacanthos L.	naturalized	artificial, natural	Intensive planting of this species in hedges has led to its spontaneous spread to natural habitats. Because of large thorns, animals avoid it, which contributes to its easy and rapid spread. Populations of this species are very common in riparian lowland forests, where it has successfully expanded into natural communities[1,5]
Juglans nigra L.	casual	forest culture, natural	This species is intensely planted in the form of forest monocultures, or in arches, and has spread to steppes on the sands[1,5] Today, *Juglans nigra* is mainly cultivated in Vojvodina, where the oldest culture was established in the vicinity of the Abyss, and is mostly cultivated in the Deliblato Sands and Fruska Gora[2]
Maclura pomifera (Raf.) C. K. Schneid. (*Maclura aurantiaca* Nutt.)	casual	artificial, natural	Mostly it is gone wild from the places where it is planted, around farms, vineyards and on the outskirts of parks[1,5]
Populus x *canadensis* Moench	naturalized	culture, natural	Rare, occurs subspontaneously[1,5]
Prunus serotine Ehrh.	casual	artificial, natural	Rare, occurs subspontaneously [1,4,5]
Rhus typhina L.	naturalized	forest culture, artificial, natural	In the last 20 years in Vojvodina, this species has been used for afforestation of the steppe. The species spread spontaneously from the original plantations, where it was used for afforestation[1,5]
Robinia pseudacacia L.	naturalized	forest culture, artificial, natural	Subspontaneously quite widespread. Among other, it occurs in the riparian zone of aquatic ecosystems. It is cultivated in Serbia to such an extent that many consider it an indigenous species[2]. It was especially used in the amelioration of Deliblato and Suborica sands. In Serbia, stands of black locust generate 11,243,944 m³, or 3.1% of the total timber volume of our forests, making it the most commonly grown allochthonous species [1,2,4,5]
Ulmis pumila L.	casual	artificial, natural, subspontaneously	For example Zasavica[1,4,5]

Exotic species in forest cultures			
Abies grandis Lindl.	introduced	forest culture and plantations	In the „Majdanpečka domena" is a culture of this species, established mountain beech site (*Fagetum moesiacae submontanum*), about 35 years old[2]. Seed object, group of trees – FMU „Klekovica" 94b[3]
Picea sitchensis (Bong.) Carr	introduced	forest culture and plantations	It occurs in young forest cultures (Jovanovic, 1992). In the Majdanpek domain, there is a culture established at the mountain beech site (*Fagetum moesiacae submontanum*), about forty years old[2]
Pseudotsuga menziesii (Mirb.) Franco	introduced	forest culture and plantations	The most widely grown conifer in our cultures, and second among all allochthonous species, after black locust. Many cultures of this species have been established at the sites of oak and beech forests. Most cultures are found in northern Sumadija[2]. Seed stands: FMU "Zeljin", 35f, 102s; G. Kovilje-Rabrovica, 44j; Bukovik 1 71e; Bukovik Mratinja 68b, c; Golubac-Dubovac 5g; Culture - Majdan-Kučajna 4J; Group of Trees - FMU Kosmaj 16b[3]
Pseudotsuga menziesii (Mirb.) Franco subsp. *macrocarpa* (Vasey) E. Murray	introduced	forest culture and plantations	It is very rarely grown in Serbia, with only one mixed culture with *Pseudotsuga menziesii* (Mirb.) Franco, near Vrnjačka Banja, established in 1963[2]
Pinus contorta Dougl.	introduced	forest culture and plantations	There are two cultures in Serbia, in Oplenac and Jastrebac, in the locality Ravnište[2]
Pinus jeffreyi Grev. et Balf	introduced	forest culture and plantations	It is grown on Deliblato sand (Vrcelj Kitić, Drakulić, 1970), on Avala, Zlatibor and Veliki Jastrebac[2]
Pinus ponderosa Dougl.	introduced	forest culture and plantations	Part of the planted seedlings remained in the Zlatibor forest nursery and part was transplanted to the sites Mitrovac on Tara and Suplja Stena on Avala[2]
Pinus strobus L.	introduced	forest culture and plantations	A widespread species in Serbia, cultivated in parks and forest cultures. There is a cultures all over Serbia, the oldest one was established in 1910 in Deliblato Sand[2]. Seed stand - FMU "Golubac-Dubovac", 5r[3]
Pinus banksiana Lamb.	introduced	forest culture and plantations	Rarely grown in forest cultures where it has not shown satisfactory success[2]
Taxodium distichum Rich.	introduced	forest culture and plantations, at green areas	The oldest culture was established in Serbia during World War II near Backa Palanka, on the site of the Donjopalanacka Ada[2]. The remains of culture established in the 1980s are on Veliko Ratno Ostrvo
Juniperus virginiana L.	introduced	forest culture and plantations	In Serbia, this species is most grown in Vojvodina, especially in Banat[2]
Chamaecyparis lawsoniana (Murr.) Parl.	introduced	forest culture and plantations	There is a culture on Mount Jelova Gora founded in 1960[2]
Quercus rubra L.	introduced	forest culture and plantations	In Serbia there are younger stands in several localities, e.g. on Jastrebac at the sites Jablanička reka (11.5 ha) and Lomnička reka (1.5 ha)[2]. Group of Trees – Kosutnjacke sume, 4a; Seed stand – Trstenicke sume, 2c; etc.[3]
Populus deltoides Bartr. ex Marsh.	introduced	forest culture and plantations	It is one of two parental species (together with *Populus nigra* L.) from which hybrid (*Populus canadensis*) were formed. Plantations contribute 1.7% of total timber volume of forests in Serbia[2]
Acer saccharum Marsch.	introduced	forest culture and plantations	It has been grown in forest cultures since 1914, when it was planted on Deliblato Sand in Vojvodina. It has been treated as an invasive species targeted for suppression in Veliko Ratno Ostrvo protected area[2]
Populus deltoides Marshall.	introduced	forest culture and plantations	Zasavica[2]
Populus x *canadensis* = *Populus* x *euroamericana* 'robusta', 'serotina', 'merilandica'	introduced	forest culture and plantations	Zasavica[2]

Exotic species as seed sources			
Abies nordmanniana (Steven) Spach	introduced	seed sources (conifer species)	Group of trees FMU ,,Avala" 16b[2]
Abies concolor (Gordon) Lindley ex Hildebrand	introduced	seed sources (conifer species)	Group of trees (4), FMU ,,Avala" 15k[2]
Larix decidua Mill.	introduced	seed sources (conifer species)	Seed Stands: FMU „Željin", 35n; FMU "Srndaljska reka", 85; FMU „Inventory of Požega Forests" 23d[2]
Cedrus atlantica (Endl.) Manetti ex Carrière	introduced	seed sources (conifer species)	Seed trees[3] – Nursery Sremcica; FMU ,,Avala", 21e; FMU ,,Kosmaj"16 b, 4a[2]
Cedrus libani A. Rich.	introduced	seed sources (conifer species)	Seed tree – Park, the village of Rudnik[2]
Ulmus pinnato-ramosa Dieck. = kultivar *Ulmus pumila* L.	introduced	seed objects (hardwood species)	Group of trees FMU ,,REIK-Kolubara" 51a, 51b [2]

Other exotic species			
Prunus padus L.	casual	artificial, natural	Subspontaneous, sporadic, insufficiently known[3]
Catalpa bignonioides Wal.	casual	-	-
Platanus orientalis L.	introduced	-	-
Sophora japonica L. (=*Styphnolobium japonicum* (L.) Schott)	introduced	-	-
Citrus pyriformis Hassk.	introduced	-	-

Note:

Naturalized species are defined as exotic plants that consistently reproduce and sustain populations over multiple life cycles without direct human intervention, and do not necessarily invade natural, semi-natural or human-created ecosystems (approach by Anackov et al. 2013).

Species with casual status are exotic species that can flowering and occasionally reproduce in an area but do not form self-sustaining populations but instead rely on reintroduction for survival (Anackov et al 2013 approach).

Sources:

[1] Anačkov G., Rat M., Radak B., Igić R., Vukov D., Rućando M., Krstivojević M., Radulović S., Cvijanović D., Milić D., Panjković B., Szabados K., Perić R., Kiš A., Stojšić V., Boža P. (2013). Alien invasive neophytes of the Southeastern part of the Pannonian Plain. Cent. Eur. J. Biol. 8(10):1032-1047

[2] Perović M., Cvjetićanin R. (2015): Severnoameričke vrste u šumskim kulturama i plantažama u Srbiji. Šumarstvo 3: 75-88.

[3] Tomić Z., Rakonjac Lj., Isajev V. (2011). Izbor vrsta za pošumljavanje i melioracije u centralnoj Srbiji, Institut za šumarstvo, Beograd

[4] Lazarević P., Stojanović V., Jelić I., Perić R., Krsteski B., Ajtić R., Sekulić N., Branković S., Sekulić G., Bjedov V. (2012). Preliminarni spisak invazivnih vrsta u Republici Srbiji sa opštim merama kontrole i suzbijanja kao potpora budućim zakonskim aktima. - Zaštita prirode 62(1): 5-31

[5] Stojanović V., Jovanović I. (2018). Pregled invazivnih i potencijalno invazivnih vrsta biljaka u Republici Srbiji i okruženju. Zaštita prirode Br. 68/1-2: 41-59

Annex 8.1. Documents related to the use of forest genetic resources in Serbia

Documents	
Strategies	Forestry development strategy of the Republic of Serbia (2006)
	Biodiversity strategy of the Republic of Serbia for the period 2011-2018 (2011)
	National agriculture and rural development strategy of the Republic of Serbia for the period 2014-2024 (2014)
Laws	Law on recognition of agricultural and forest plant varieties (1998)
	Law on forest reproductive material (2004)
	Law on environmental protection (2004)
	Law on nature protection (2009)
	Law on forests (2010)
	Law on game and hunting (2010)
	Law on agriculture and rural development (2009)
	Law on genetically modified organisms (2009)
	Law on national parks (2015)
Bylaws	The Decision to place plant species under protection as natural rarities (1990)
	Decree on the Protection of Natural Rarities (1993)
	Regulation on the recognition of starting material and control of production of reproductive material of forest trees (2005)
	Decree on putting under control the use and trade of wild flora and fauna (2005)
	Regulation on small quantities of forest seed and forest seedlings (2008)
	Regulation on the quality of reproductive material of poplar and willow (2009)
	Rulebook on declaration and protection of strictly protected and protected wild species of plants, animals and fungi (2010)
	Regulation on balance of forest reproductive material (2011)

Annex 8.2. Area and number of seed stands by species in Serbia for production of selected reproductive material

Species	Number of seed stands	Area (ha)
Abies alba	8	143,47
Abies grandis	1	0,18
Picea abies	15	264,08
Picea omorika	3	14,7
Pinus sylvestris	5	39,75
Pinus nigra	8	112,17
Pseudotsuga menziesii	4	6,53
Pinus peuce	1	1,82
Larix decidua	2	0,26
Cedrus atlantica	4	0,45
Taxodium distichum	1	0,22
Fagus sylvatica	20	216,03
Quercus robur	16	786,58
Quercus petraea	13	82,81
Quercus rubra	2	0,48
Quercus frainetto	9	145,78
Acer pseudoplatanus	7	19,52
Acer heldreichii	1	N/A
Acer platanoides	2	4,02
Acer dasycarpum	1	N/A
Fraxinus excelsior	5	4,04
Fraxinus angustifolia	2	57,85
Ulmus pumila	1	N/A
Ulmus montana	3	4,02
Robinia pseudoacacia	6	35,98
Tilia tomentosa	2	1,9
Tilia platyphyllos	2	20,25
Betula pendula	2	N/A
Carpinus betulus	1	50,37
Corylus colurna	5	0,88
Juglans regia	1	N/A
Juglans nigra	6	7,22
Castanea sativa	1	0,35
Aesculus hippocastanum	1	N/A
Platanus x acerifolia	3	N/A
Prunus avium	6	49,33
Celtis occidentalis	2	1
Gleditsia triacanthos	1	0,39
Sorbus torminalis	1	N/A
Sorbus aucuparia	1	N/A
Elaeagnus angustifolia	1	N/A
Evodia hupehensis	1	N/A
Quercus robur, Fraxinus excelsior	1	29,78
Fagus moesiaca, Abies alba	1	9,62

(Source: DOF, 2020)

Annex 8.3. Area and number of seed sources by species in Serbia for production of reproductive material of known origin

Species	Number of seed sources	Area (ha)
Abies alba	3	33,80
Picea abies	17	433,56
Pinus sylvestris	3	457,01
Pinus nigra	13	1713,06
Pseudotsuga menziesii	3	20,29
Cedrus atlantica	1	0,66
Fagus sylvatica	67	2355,90
Quercus robur	47	17327,41
Quercus petraea	32	775,82
Quercus frainetto	5	42,73
Quercus pubescens	1	0,82
Quercus cerris	15	445,37
Quercus rubra	4	2,83
Acer pseudoplatanus	17	74,17
Acer platanoides	2	6,43
Acer heldreichii	2	33,59
Acer campestre	1	0,19
Fraxinus excelsior	7	30,80
Fraxinus angustifolia	17	234,66
Fraxinus ornus	1	22,89
Ulmus pumila	9	2,11
Ulmus montana	1	27,72
Robinia pseudoacacia	29	252,46
Tilia tomentosa	6	291,39
Tilia cordata	7	35,10
Tilia platyphyllos	5	N/A
Betula pendula	7	N/A
Carpinus betulus	2	4,70
Alnus glutinosa	4	N/A
Corylus colurna	6	N/A
Juglans regia	4	N/A
Juglans nigra	10	49,22
Castanea sativa	4	N/A
Aesculus hippocastanum	3	N/A
Platanus x acerifolia	2	N/A
Prunus avium	12	238,52
Pyrus piraster	5	6,70
Malus sylvestris	7	N/A
Celtis australis	1	N/A
Celtis occidentalis	2	N/A
Gleditsia triacanthos	6	9,63
Sorbus torminalis	2	0,96
Sorbus scandica	1	N/A
Sorbus aria	1	N/A
Sorbus aucuparia	3	N/A
Sorbus domestica	4	10,21
Cornus mas	2	N/A
Evodia hupehensis	3	5,68
Paulownia fortunei	1	0,50
Paulownia tomentosa	1	N/A
Paulownia elongata	2	0,50
Prunus cerasifera	2	N/A
Morus alba	3	1,29
Morus nigra	1	N/A
Sophora japonica	3	N/A
Catalpa bignonioides	2	N/A
Elaeagnus angustifolia	1	N/A
Prunus mahaleb	1	N/A
Salix alba	1	12,13

(Source: DOF, 2020)

Annex 9.1. Registered willow and poplar varieties in Serbia

Species	Variety	Year	Country
Willow	*Salix alba cl. NS-107-6*	1980	Federal Republic of Yugoslavia
Willow	*Salix alba cl. NS-73-6*	1980	Federal Republic of Yugoslavia
Willow	*Salix alba cl. NS-79-2*	1980	Federal Republic of Yugoslavia
Poplar	*Populus deltoides cl. 457*	1980	Federal Republic of Yugoslavia
Poplar	*Populus deltoides cl. 55-65*	1980	Federal Republic of Yugoslavia
Poplar	*Populus deltoides cl. S-1-8*	1987	Federal Republic of Yugoslavia
Poplar	*Populus deltoides cl. S-6-20*	1987	Federal Republic of Yugoslavia
Poplar	*Populus deltoides cl. S-6-36*	1987	Federal Republic of Yugoslavia
Willow	*Salix alba cl. 107-65-1*	1987	Federal Republic of Yugoslavia
Willow	*Salix alba cl. 107-65-7*	1987	Federal Republic of Yugoslavia
Poplar	*Populus deltoides cl. NS 1-3*	1990	Federal Republic of Yugoslavia
Poplar	*Populus x euramericana cl. NS 11-8*	1998	Federal Republic of Yugoslavia
Poplar	*Populus deltoides cl. Novi Sad-1*	2002	Republic of Serbia
Poplar	*Populus deltoides cl. Novi Sad-2*	2002	Republic of Serbia
Willow	*Salix alba cl. Volmjanka*	2012	Republic of Belarus
Willow	*Salix alba cl. Drina*	2012	Republic of Belarus
Willow	*Salix alba cl. Backa*	2012	Republic of Belarus
Poplar	*Populus deltoides cl. B-81*	2014	Republic of Serbia
Poplar	*Populus deltoides cl. Bora*	2018	Republic of Serbia

(Source: http://www.ilfe.org/sr/varieties)

Annex 9.2. Properties that have been improved in various breeding programs or activities

Species	Properties								
	Drought resistance	**Resistance on the diseases**	**Growth and increase**	**Predilection on insects**	**Wood properties**	**Phytoremediation potential**	**Crop/ offsprings**	**Phenology**	**Decorative properties of leaves**
White willow (*Salix alba* L.)[1]		+	+						
Beech (*Fagus* sp.)[2]									+
European white elm (*Ulmus laevis* Pall.)[3]						+	+		
Sycamore (*Acer pseudoplatanus* 'Atropurpureum')[4]									+
Euro-American poplar (*Populus x euramericana* (Dode) Guinier)[5]		+	+						
Lime trees (*Tilia* spp)[6]						+			
Pedunculate oak (*Quercus robur* L.)[7]							+	+	
Serbian spruce (*Picea omorika*/Panč./Purkyne)[8]							+		
Narrow-leafed ash (*Fraxinus angustifolia* Vahl.)[9]							+		
Eastern cottonwood (*Populus deltoides* Marschall)[10]	+	+	+	+	+	+			
Bald cypress (*Taxodium distichum* (L.) Rich.)[11]							+		
Black poplar (*Populus nigra* L.)[12]							+		
European hop-hornbeam (*Ostrya carpinifolia* Scop.)[13]							+		

***Sources*:**
[1]http://www.ilfe.org
[2] Nonić, 2016; Nonić et al. 2017c
[3] Devetaković et al., 2016; Devetaković, 2017
[4] Šijačić-Nikolić et al., 2006, 2009, 2011
[5] http://www.ilfe.org/sites/default/files/Populus%20x%20euramericana%20cl.%20NS%2011-8.pdf
[6] Šijačić-Nikolić et al., 2012
[7] Šijačić-Nikolić et al., 2019
[8] Tucović et al., 1983, 1988; Isajev, 1987; Šijačić-Nikolić, 2000
[9] Šijačić-Nikolić et al., 2018
[10]http://www.ilfe.org/sites/default/files/Populus%20deltoides%20cl.%20Bora_1.pdf
[11] Popović, 2013; Popović et al., 2013, 2014
[12] Maksimović et al, 2014; Maksimović, 2015; Šijačić-Nikolić, 2018
[13] Ivetić et al., 2015