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CONSERVATION OF BIODIVERSITY AND FOREST GENETIC RESOURCES IN SERBIA

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The Republic of Serbia is ranked among the countries with high endemism and a very high floristic diversity. Forest genetic resources (FGR) take a significant place in the total biodiversity of Serbia, including about 250 indigenous tree species. This paper was aimed to give a review of the state of biodiversity and forest genetic resources in Serbia, and previous activities on conservation of these resources. Today we are recording a large number of various destructive activities, which significantly reduce areas under forests. Conservation of forest genetic resources should be considered as the efforts to preserve specific genotypes or populations and the combination of genes within them. The first step in the conservation of forest genetic resources provides the protection of biodiversity which is essential for present and future human well-being. The predominant form of FGR conservation in Serbia is *in situ*, which is mainly applied through the establishment of seed stands, but different types of *ex situ* conservation are also applied, through seed orchards, progeny tests, and provenance trials. An important gene pool is kept in the arboreta and botanical gardens.

Keywords: *in situ*, *ex situ*, FGR conservation, forest, ecosystem.

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INTRODUCTION

Various human activities have led to irreversible processes that have directly affected the loss of biodiversity. The biodiversity loss is reflected in the extinction of species and populations, ecosystem degradation, erosion of genetic diversity and evolutionary potential, and loss of ecological services (Groom et al., 2006; Šijačić-Nikolić, Nonić, 2019). The causes of biodiversity loss are numerous, such as habitat alteration, pollution, population growth, overexploitation, invasive species, and climate changes, which affect all aspects of biodiversity (Brennan, Withgott, 2004; Šijačić-Nikolić, Milovanović, 2007; Šijačić-Nikolić, Nonić, 2019). These factors that threaten biodiversity are usually

anthropogenic character and mutually dependent. The observed effects of climate change on biodiversity and natural ecosystems in Serbia indicate that changes in physiology, phenology, the morphology, number and distribution of species can occur, as well as in the loss of habitats; increasing the number of pests and diseases, etc.

Biodiversity protection is based on determining the scientific basis, legislation and the activities carried out in practice (Šijačić-Nikolić et al., 2014a). In addition to preserving the environment, biodiversity conservation represents very important mission in global environmental protection.

Forest ecosystem baseline consists of different forest tree species, whose gene pool is the basic unit of biodiversity. Forests are characterized by diffe-

rent functions. Forests have an important role in the overall biodiversity since forest woody plants provide habitat to other organisms. Thanks to genetic variability, trees can adapt to new environmental conditions (Šijačić-Nikolić, Milovanović, 2007, 2010; Šijačić-Nikolić et al., 2014a; Nonić, Šijačić-Nikolić, 2019).

Forest genetic resources (FGR), which take a significant place in biodiversity of Serbia, can be defined as the genetic variation of trees that are of actual or potential value for humans (Plant genetic resources..., 1989) and represent a source of environmental, social, and economic values for numerous human generations.

This paper was aimed to give a review of the state of biodiversity and forest genetic resources in Serbia, and some previous activities on conservation of these resources.

BIODIVERSITY RICHNESS AND PROTECTED NATURAL HERITAGE OF SERBIA

The Republic of Serbia is characterized by high biodiversity, especially floristic diversity, with more than 40 000 different species and subspecies and more than 3600 recorded taxa of vascular plants (The Fifth National Report..., 2014; Institute..., 2019). Experts assume that in the Republic of Serbia may occur approximately 60 000 taxa (Biodiversity..., 2011). The Serbian biodiversity includes a large number of different fungi (more than 600 species), lichen (586), fish (about 100 taxa), mammals (94 taxa), approximately 360 taxa of birds, etc. (Institute..., 2019). Vascular plants are among the most numerous in Serbia (Amidžić et al., 2014).

There are five national parks in Serbia which represent an important way of *in situ* FGR conservation, containing the best-preserved parts of nature,

and are therefore one of the most common methods of conserving endemism and areas rich in flora and fauna (Šijačić-Nikolić et al., 2006; Popović et al., 2017). About 1.5 % of the Serbian flora represents local endemics (Institute..., 2019).

Different high mountain regions, sand and steppe habitats, and refugial areas in Serbia are very rich in ecosystem diversity.

Conservation in protected areas presents the important aspect of *in situ* FGR conservation. The number of protected areas in Serbia is 473, which covers 6 % of the Serbian territory. An increase of up to 10 % of the total territory has been envisaged until 2015, i. e. 12 % until 2021.

Table shows protected areas per category and surface in Serbia.

Protected areas in Serbia can be managed by legal entities (public enterprises for forest management, tourism organizations, units of local self-government, scientific and educational institutions, etc.), religious communities, non-government organizations, etc. (Amidžić et al., 2013).

FOREST GENETIC RESOURCES AND ITS CONSERVATION IN SERBIA

National Forest Inventory of Serbia (Banković et al., 2009a) recorded 40 deciduous and 9 coniferous species of trees, of which 38 belong to endemic, relict, rare and endangered species (Banković et al., 2009b). The special attention is given to 88 wild fruit species, species of limited geographic distribution, as well as medicinal and aromatic herbs, etc. (Biodiversity..., 2011). In Serbia, 53 % belong to state forests and 47 % to private forests (Banković et al., 2009a).

Today we are recording a large number of various destructive activities, which significantly reduce areas under forests, especially in populations of

Protected areas in Serbia

Protected area	Serbia without KiM*	KiM*	Area, ha
National parks	4	1	158 986
Nature parks	17	1	213 768
Protected landscapes	15	1	45 656
Nature reserves	63	6	98 954
Protected habitat	3	0	1120
Natural monument	288	35	10 306
Areas with cultural and historical significance	34	5	2489
Total	424	49	531 279

Note. * The data in the table given in the book of J. Milovanović and S. Đorđević-Milošević (2016).

forest trees with limited or disjunctive areal and in rare ecotypes within a limited habitat (Milovanović, Đorđević-Milošević, 2016).

FGRs in Serbia are broadly affected by negative anthropogenic influence, different abiotic and biotic threats, and climate changes (Stojnić et al., 2019).

The FGR conservation is the subject of strategies, laws and programs from the fields of forestry, sustainable development, environmental and nature protection in Serbia (Milovanović et al., 2012; Nonić et al., 2019). The National program of conservation and sustainable utilization of FGR for the period 2016–2025 was adopted in 2016 and is directly related to FGR conservation.

The predominant form of FGR conservation in Serbia is *in situ* (the maintenance of FGR in natural populations and protected areas), but different types of *ex situ* conservation (the maintenance of FGR outside their natural habitats) are also applied.

In situ and ex situ FGR conservation methods applied in Serbia. *In situ* conservation of FGR in Serbia is mainly applied through the establishment of seed stands, which implies stands of a high level of tree quality, good health status, and phenotypic characteristics. There are 212 seed stands in Serbia, where 58 are seed stands of coniferous and 154 are of deciduous species (Šijačić-Nikolić et al., 2014b).

According to V. Popović and A. Lučić (2019), the *in situ* conservation in Serbia is most often used in populations that are naturally regenerated in protected natural areas, and in regularly managed forests where is mainly achieved through the selection of the seed stands, group of trees or individual trees.

To meet the criteria for inclusion in the OECD (The Organization for Economic Cooperation and Development) scheme, the Republic of Serbia has so far adopted a decision on the establishment of provenance regions of Sessile oak *Quercus petraea* (Matt.) Liebl., pedunculate oak *Quercus robur* L., beech *Fagus* L., fir *Abies* Mill., Norway spruce *Picea abies* (L.) H. Karst., Austrian pine *Pinus nigra* J. F. Arnold, and ash *Fraxinus* L. in the area of the state (Šijačić-Nikolić et al., 2016).

According to the previous review, *ex situ* conservation is applied in Serbia through the establishment of seed orchards, progeny tests, and provenance trials, as well as clone archives of fast-growing species (Šijačić-Nikolić et al., 2014b, 2016, 2017). An important gene pool is kept in the arboreta and botanical gardens. Classical methods of static *ex situ* conservation of forest trees (seed banks, pollen, DNA, in vitro explants and cryopreservation) are not yet sufficiently developed and applied in Serbia.

CONCLUSIONS

Although biodiversity research is continuously carried out, there is still an insufficient level of scientific data when it comes to flora and fauna of Serbia. Insufficient implementation of legislation in the field of nature and biodiversity protection, the lack of biodiversity protection policy in the production sectors and insufficient application of existing protection mechanisms lead to ineffective conservation. In the eternal conflict between the conservation of nature and economic interest, biodiversity protection is still considered an obstacle to development. Moreover, although the area of biodiversity protection is included in various sectoral strategies and programs, its priority remains inadequate in practice.

The first step in the FGR conservation presents the protection of biodiversity. Having in mind the above difficulties in this area, the assumption is that directed activities in such a specific and narrow area are even more difficult. The regulatory basis of FGR conservation in Serbia is found in the strategic and legal acts in the field of environmental and nature protection, forestry, and sustainable development.

Significant progress in this area has been achieved by a team of researchers from all relevant institutions and with the support of the Ministry of Agriculture, Forestry and Water Management – Directorate for Forests, through the development of the National Program (Šijačić-Nikolić et al., 2016) which elaborates on all important aspects and defines priorities and measures in the area of FGR conservation relied on biodiversity and nature protection. Interdisciplinarity and cross-sectoral collaboration are essential in achieving sustainability through diversity conservation.

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СОХРАНЕНИЕ БИОРАЗНООБРАЗИЯ И ЛЕСНЫХ ГЕНЕТИЧЕСКИХ РЕСУРСОВ В СЕРБИИ

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Республика Сербия входит в число стран с большим количеством эндемиков и высоким флористическим разнообразием. Лесные генетические ресурсы (ЛГР), в том числе около 250 местных пород деревьев, занимают значительное место в общем биоразнообразии Сербии. В статье приводится обзор состояния биоразнообразия и лесных генетических ресурсов в Сербии, а также мероприятий по их сохранению, которые проводились в стране. Сегодня фиксируется большое количество различных разрушительных воздействий, которые приводят к значительному сокращению площади лесов. Сохранение лесных генетических ресурсов предполагает усилия по сохранению конкретных генотипов или популяций и комбинации генов внутри них. Первым шагом в сохранении лесных генетических ресурсов является защита биоразнообразия, что необходимо для настоящего и будущего благосостояния людей. Преобладающей формой сохранения ЛГР в Сербии является *in situ*, которая в основном применяется путем создания семенных насаждений, но также применяются различные способы сохранения *ex situ* через семенные сады, тесты на потомство и испытания на предмет происхождения. Важный генофонд хранится в дендропарках и ботанических садах.

Ключевые слова: *in situ*, *ex situ*, сохранение ЛГР, лес, экосистема.