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CONSERVATION AND SUSTAINABLE USE OF FOREST GENETIC RESOURCES THROUGH AN EXAMPLE OF WETLAND ECOSYSTEMS

ABSTRACT

Forest genetic resources represent the genetic diversity contained in thousands of forest tree species on Earth. The conservation of these resources should be seen as efforts to preserve the specific genotypes or populations and the characteristic combination of genes in them. The basis for the conservation of forest genetic resources is the genetic variability of natural populations, which is the result of different genetic processes: mutations, recombination, gene flow, natural selection and genetic drift. The principles of conservation of genetic variation can be considered identical for all living beings. However, the methods used vary depending on the specific goals of conservation, distribution and nature of biological material that is the object of conservation. From the standpoint of preserving genetic variability, we can talk about the different "methods" of conservation. The term "method" is used in the context of a particular concept of conservation of genetic resources: in situ or ex situ, dynamic or static, while the species, ecosystems, populations, individuals or parts of individuals are concerned as an object of conservation.

Principles and methods of conservation are shown through the example of wetlands as is the Great War Island in Belgrade. Given the importance of wetlands and their vulnerability to current climate changes, we believe that this example is up to date. Strategy for genetic conservation of this area is based on the adaptation to improve ecological and evolutionary potential of populations of rare and endangered forest tree species to establish the basis for the controlled production of selected plant material and the surface extension of the genetic resources.

Keywords: forest genetic resources, conservation, example, wetlands

INTRODUCTION

Wetlands, as is the Great War Island in Belgrade, are the transition area between terrestrial and aquatic ecosystems and are characterized by the presence of plant and animal species dependent to a greater or lesser degree of water amount. The main objective of the Ramsar Convention is protection and wise use of these sensitive ecosystems through the implementation of appropriate

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measures at the national level, with international collaboration where necessary, as a means of achieving sustainable development. Wise use of wetlands is the maintenance of their ecological character through the application of ecosystem approach in the context of sustainable development (Anonimous, 2007). Wetlands are popularly known as "biological supermarkets" because of interwoven food chains and rich biodiversity, but also as "the Planet's kidneys" because of the role played by the hydro-geological and chemical cycles (Mitsch & Gosselink, 1993).

Given the importance of wetlands and their vulnerability to current climate change, the implementation of the concept of genetic conservation is one of the main ways to preserve and improve these ecosystems. Forest woody species are one of the main wetland plant categories, and high level of genetic diversity is necessary for the viability of their populations.

Forest genetic resources represent the genetic diversity contained in thousands of forest tree species on Earth. The conservation of these resources should be seen as efforts to preserve the specific genotypes or populations and the characteristic combination of genes in them. The basis for the conservation of forest genetic resources is the genetic variability of natural populations, which is the result of different genetic processes: mutations, recombination, gene flow, natural selection and genetic drift. The principles of conservation of genetic variation can be considered identical for all living beings. However, the methods used vary depending on the specific goals of conservation, distribution and nature of biological material that is the object of conservation. From the standpoint of preserving genetic variability, we can talk about the different "methods" of conservation. The term "method" is used in the context of a particular concept of conservation of genetic resources: *in situ* or *ex situ*, dynamic or static, while the species, ecosystems, populations, individuals or parts of individuals are concerned as an object of conservation (Šijačić-Nikolić et al., 2010).

MATERIALS AND METHODS

The Great War Island is located in the city of Belgrade, Municipality of Zemun, at the altitude from 69.5 to 73.5 meters. It has been created as a sedimentary and alluvial-accumulative formation due to slowing and stopping of sandy sediments at the confluence of the Sava and Danube. It is built of concentric plant zones that are proper turns from the coast to the interior of the island, depending on the groundwater level and elevation of the terrain. It belongs to sensitive wetlands, which include the presence of specific vegetation, which forms a habitat for various plant and animal species.

A systematic approach to conservation of forest genetic resources requires an initial phase, which involves the collection of necessary information and identification of priorities based on known and potential risks of genetic resources. The next phase is the selection of species and populations that need to be included in the conservation program, defining of specific goals and development of management plans for specific area. The final phase involves the

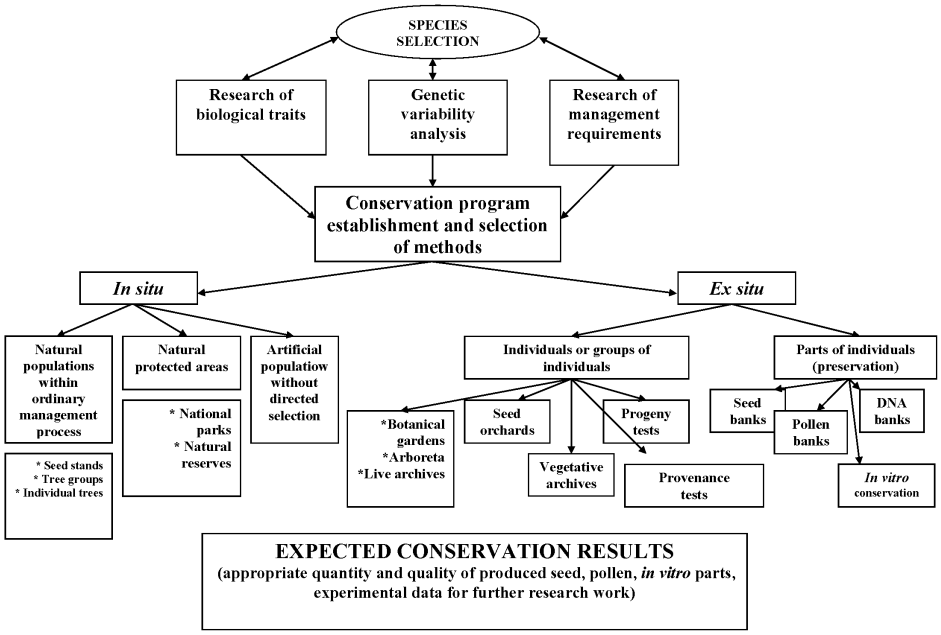
establishment of monitoring system to follow the implementation of defined objectives, management measures and compliance with the requirements of diversity conservation.

Following the adoption of the development and implementation process, the next step is selection of appropriate methods of *in situ* and *ex situ* conservation, which are in accordance with the specific requirements of the species or habitat. The development of a conservation program includes several key steps (Rotach, 2005):

- *Collection of relevant information on specific habitat;*
- *Selection of target species and priority setting;*
- *Selection of the basic methods of conservation (active, passive, dynamic, static);*
- *Identification and selection of populations for inclusion in the conservation program;*
- *Establishment of conservation requirements and goals;*
- *Defining the guidelines for managing specific ecosystem in accordance with the principles of conservation;*
- *Establishing a monitoring system to follow the implementation of defined objectives.*

In order to define the program of conservation and sustainable use of forest genetic resources of the Great War Island, after collecting basic information on this wetland habitat, a review of rare, threatened and relic species of forest trees at the territory of the protected area was established. Authors used the IUCN categorization for determination of species categories, according to which there are 38 species of trees and shrubs from the category of relic, endemic, rare and endangered in Serbian forests. These species further enrich forest ecosystems and need special attention from the point of biodiversity conservation during planning of ecological, social and economic management goals (Banković et al., 2009). Authors also consulted REFORGEN database on forest genetic resources in order to properly consider conservation status of each species. On the basis of set priorities, the selection of target species for inclusion in a program of genetic conservation was made. Selected woody species and their populations were spatially determined using the GPS coordinates of all or selected trees, if it is a species whose number of trees exceed 100 individuals. The coordinates are determined in the field, using GPS Trimble ®GeoExplorer® series, which was related to the laser rangefinder TruPulse 360B, which was also used for tree height measuring (Šijačić-Nikolić et al., 2011).

The choice of the basic methods of conservation was carried out based on the model of classification of forest genetic conservation methods (Šijačić-Nikolić, Milovanović, 2007), applying comparative analysis of the characteristics of species and their populations and the applicability principles of the offered methods:



Picture 1 Forest genetic resources conservation model
(Šijačić-Nikolić, Milovanović, 2007)

A model of *in situ* conservation field network for the Great War Island, as well as a suggestion of implementation of appropriate *ex situ* conservation methods was established according to the collected data on spatial, morphological and phenological traits of forest tree species of importance for genetic conservation.

RESULTS AND DISCUSSION

Summary of rare, threatened and relic species of the Great War Island is shown in Table 1.

From the point of genetic conservation of forest species of the Great War Island, conservation of European White Elm gene pool **(***Ulmus effusa* Willd.) can be considered as a priority**,** a species that falls into the category of rare and endangered, and its presence in this habitat decreases. There are about 50 genotypes which usually grow in dense with thick underground so that the possibility of natural regeneration has been reduced to a minimum.

Following conservation objectives, according to the order of priority are natural forests of willows and poplars, which are accounted for only 0.5 to 1.0% of the forest growing stock in Serbia and can be considered as rare and special value of this area. Therefore, the White Willow stands and stands of White and Black Poplar trees need to be protected by clearly defined program of

conservation of the gene pool of these stands at the territory of the Great War Island.

Bald Cypress (*Taxodium distichum* (L.) Rich.) as non-indigenous species that occurs mainly in individual trees in Serbia, has an important gene pool at the Great War Island contained in a number of over 80 genotypes. Until recently, these trees have been growing in dense, and some of them fully depressed, so it is necessary to pay special attention in the future to conserve the gene pool which can be considered unique in Serbia.

Gene pool of English Walnut (*Juglans regia* L.) and European Nettle Tree (*Celtis australis* L.), as species introduced by human or birds, in this area is represented with several genotypes (individuals) and it is not necessary to prescribe additional measures of conservation for these species having in mind that this is a natural protected area that includes protection measures.

Table 1: Rare, endangered and relic species of the Great War Island

Species	Category
White poplar (*Populus alba* L.)	**rare/endangered** (Banković et al., 2009 according to IUCN) **endangered** (according to REFORGEN, 2003)
European White Elm (*Ulmus effusa* Willd.)	**rare/endangered** (Banković et al., 2009 according to IUCN) **endangered** (according to REFORGEN, 2003)
English Walnut (*Juglans regia* L.)	**rare/endangered** (Banković et al. 2009 according to IUCN)
Black Poplar (*Populus nigra* L.)	**endangered** (according to REFORGEN, 2003)
European Nettle Tree (*Celtis australis* L.)	**endemic** (Banković et al., 2009 according to IUCN)
White Willow (*Salix alba* L.)	**rare**
Bald Cypress (*Taxodium distichum* (L.) Rich.)	**allochthonous/rare**

Suggestion of genetic conservation measures for rare and endangered woody species

Protection and sustainable use of genetic resources of selected rare and endangered species in the Great War Island will be implemented mainly:

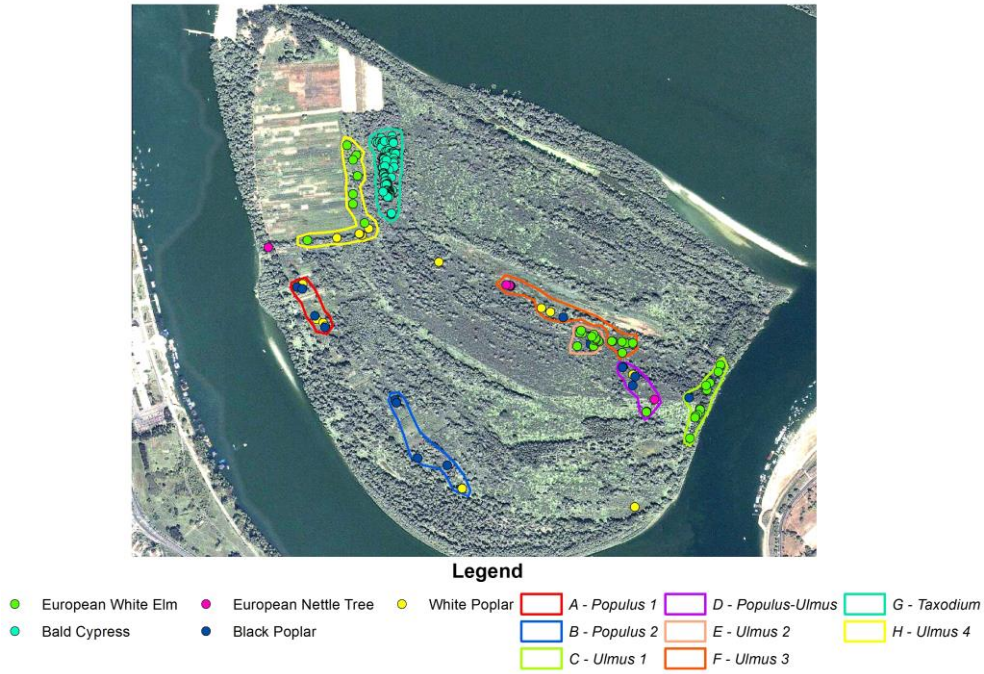
- *in situ* – through the selection of rare genotypes within populations of rare and endangered species and their integration into the network of habitat conservation of the Great War Island and

- *ex situ* – the establishment of progeny tests to further research of genetic potential of populations, generative and clonal seed orchards and seed storage of rare genotypes in the seed bank.

The *in situ* conservation network of habitats of the Great War Island, Picture 2, includes all locations where there are rare and valuable specimens of species that deserve to be included in conservation programs, such as Black and White Poplar, European White Elm and Bald Cypress, with clear labeling of Nettle Tree individuals.

Conservation fields are set aside in the order in which they are approachable by walking on the scientific and educational path of the Great War Island and they are marked with letters A through H.

Conservation fields are selected to have a uniform distribution on the surface of the island, that are located relatively close to walking trails that would be available to researchers, students and pupils in educational and scientific purposes, but primarily to include representative examples of these kinds of genotypes.



Picture 2 The network of *in situ* conservation fields for forest woody species of the Great War Island

Conservation field A, called *Populus 1*, includes four individuals of White (1-4) and four trees of Black Poplar (1-4), with a marked Nettle Tree (5), located at the very beginning of the educational path of the Great War Island.

Conservation field B, called *Populus* 2, includes four trees of Black (5-8) and one individual of White poplar (5). Furter movement on the educational path

brings to a individual tree (6) of White poplar, whose habitus brought attention and resulted with its joining to the *in situ* conservation network.

Conservation field C, called *Ulmus* 1, includes the first group of 15 European White Elm trees (1-12 and 32), which belong to the subpopulation I, and a White Poplar tree (9). This group of trees is located at the Danube shore and habitat is exposed to permanent accumulation of communal, but also hazardous waste, dumped by the Danube during water level changes. Access to this conservation field is quite difficult and it is necessary to pay attention to clearing this site, that valuable genetic resources can be available to scientists, students and pupils for research and field classes.

Conservation field D, called *Populus – Ulmus*, includes nine trees of European White Elm (13-14), which belong to the subpopulation I, four trees of Black poplar (10-13) and one tree of White Poplar (7), with clear marking of a Nettle Tree (6).

Conservation field E, called *Ulmus* 2, includes population of 15 trees of European White Elm (15-26), which belong to the subpopulation II, and which are distributed on both sides of the educational path, and one tree of Black Poplar (14).

Conservation field F, called *Ulmus* 3, includes a group of seven European White Elm trees (33-39), which belong to the subpopulation II and are located at the right side of the educational path.

By further movement on the educational path we are approaching to a single tree of Black Poplar (15) and two individual trees of White poplar (8-9), and near them there is a group of clearly marked Nettle Trees (1-4). Individual tree of White poplar (10) is also clearly marked because of its special traits and assessed genetic potential.

Conservation field G, called *Taxodium*, includes population of 83 Bald Cypress trees, clearly spatially defined and characterized through the assessment of morphological traits.

Conservation field H, called *Ulmus* 4, includes a group of 10 European White Elm trees (27-31 and 40-42), which belong to the subpopulation III and five trees of White Poplar (11-15).

CONCLUSION

The basic vision of the genetic conservation of forest species of the Great War Island is a long-term conservation and enhancement of environmental adaptability and evolutionary potential of populations of rare and endangered trees in this area and lay basis for the controlled production of selected planting material in order to expand the area under the genetic resources of species. To realize this vision, adequate *in situ* and *ex situ* conservation measures are prescribed, appropriate to the species characteristics and potentials.

Selected and marked *in situ* conservation fields which are networked into a single system at the entire territory of the Great War Island, have a role of representative visibility tool for genetic potential of forest tree species of this

natural protected area. The main function of the network is educational, but it is also a well-planned basis for long-term conservation and enhancement of the degree of variability and vitality of forest ecosystems in the Great War Island. All conservation fields will be clearly marked and visible, with emphasis on easily readable and understandable information about their significance for environmental protection and biodiversity conservation.

Full participation of all stakeholders and beneficiaries in the implementation of the program is necessary. Successful implementation of the prescribed conservation contributes to the fact that some of the activities can be realized in the ordinary mode of taking care of the Great War Island as a protected natural area, with good cooperation between natural area managers and research institutions. Other activities require the continuation of research initiated in order to concretize all prescribed measures of the program.

Methodology for genetic conservation programs development, which is presented in this paper through the example of the natural protected area "Great War Island", is a universal model whose basic principles can be applied in all cases of programming and planning of goals and methods of forest genetic resources conservation.

It should be noted that this basic draft of the genetic conservation program methodology cannot serve as a rule and be followed step by step without any changes. It primarily serves to indicate the complexity of a systematic approach to the development of conservation programs. The concept of activities requires modifications depending on the specific species or habitats.

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KONZERVACIJA I USMERENO KORIŠĆENJE ŠUMSKIH GENETIČKIH RESURSA NA PRIMERU VLAŽNIH KOSISTEMA

SAŽETAK

Šumski genetički resursi predstavljaju genetički diverzitet sadržan u hiljadama vrsta šumskog drveća na Zemlji. Konzervaciju ovih resursa treba posmatrati kao napore u cilju očuvanja specifičnih genotipova ili populacija i karakterističnih kombinacija gena u njima.

Osnovu za konzervaciju šumskih genetičkih resursa predstavlja genetička varijabilnost prirodnih populacija, koja je rezultat različitih genetičkih procesa: mutacija, rekombinacija, protoka gena, prirodne selekcije i genetičkog drifta.

Principi konzervacije genetičke varijabilnosti mogu se smatrati identičnim za sva živa bića. Međutim, metode koje se primenjuju variraju u zavisnosti od specifičnosti ciljeva konzervacije, distribucije i biološke prirode materijala koji je objekat konzervacije.

Sa aspekta očuvanja genetičke varijabilnosti možemo govoriti o različitim «metodama» konzervacije. Termin «metod» se koristi u kontekstu određene koncepcije konzervacije genetičkih resursa: *in situ* ili *ex situ*, dinamična ili statična, dok se vrsta, ekosistem, populacija, individua ili deo individue smatraju objektom konzervacije.

Osnovni principi i metode konzervacije biće prikazane na primeru vlažnih staništa kakvo je Veliko ratno ostrvo. Imajući u vidu značaj vlažnih staništa i njihovu ugroženost aktuelnim klimatskim promenama, smatrali smo da je ovaj primer trenutno najaktuelniji. Strategiju genetičke konzervacije ovog područja bazirali smo na unapređenju ekološke adaptivnosti i evolutivnog potencijala populacija retkih i ugroženih šumskih drvenastih vrsta uz postavljanje osnova za kontrolisanu proizvodnju selekcionisanog sadnog materijala i proširenje površine pod genetičkim resursima.

Ključne riječi: šumski genetički pesursi, konzervacija, primer, Veliko ratno ostrvo