The program of forest genetic resources conservation in Republic of Srpska 2013-2025

Banja Luka, December, 2013

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Pursuant to the Article 43. Paragraph 7. Law on the Government of Republic of Srpska ("Official Gazette of the Republic of Srpska", No. 118/08) on its 32. meeting held on October 21 2013 the Republic of Srpska Government adopted the Program of forest genetic resources conservation in Republic of Srpska for the period between 2013-2025 (No. 04/1-012-2-2222/13).

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Content

1. INTRODUCTION

Forest genetic resources - genetic diversities as intergenerational resources of enormous social, economic and environmental importance, are present in thousands of tree species on the Earth. Carried out worldwide, the process of preservation (conservation) of forest genetic resources, aims to maintain the total genetic diversity, which is of a recognized or of potential socio-economic or ecological importance. Biological diversity, namely the diversity of living organisms and the diversity within various species, as well as between species and ecosystems, present an important resource for human existence by performing a crucial role in a sustainable development and by being a useful tool to eradicate hunger in the world. The Earth's genetic resources are of vital importance for humanity, for its economic and social development. All over the world there is a growing awareness of the benefits and usefulness of biological diversity which can be applied to the life and health of every individual, as well as the awareness of the need to preserve genetic diversity as a basis of biodiversity. As a result, biological diversity is acknowledged as a global asset of immense value, not only for present but for all future generations.

Forests present the most important repository of biodiversity on Earth. In addition, they provide people with wide range of products and services. Acting as the backbone of many other organisms, trees and other woody plants which grow in forests have developed complex mechanisms to maintain a high level of genetic diversity. This genetic variation that occurs within and between species has a number of fundamental roles. It facilitates trees and bushes to react to changes in the environment, including those caused by pests, diseases and climate change.

Conservation of forest genetic resources is considered here as a number of activities and as a policy which seeks to ensure the continuation of life, evolution and availability of these resources for present and future generations. Among the wide range of definitions (FAO-1989) referring the concept of forest genetic resources one says that: "Genetic variation of trees that are of potential or immediate benefits for the people." It is genetically related to genetic variability at the level of (DNA) origin, as well as to variations of genes at different levels: (1) variation between species, (2) variation among populations within species, and (3) variation among individual trees within the population. Bearing in mind the fact that the greatest variation occurs between species, the most dramatic damage which could happen in the future would be the loss of entire species. Resources refer to the utilization of genetic variation, - in the broader sense of what is stated above - and present a potential value for human beings in the present or in the future (Šijačić-Nikolić, M,. i Milovanović, J., 2010).

In addition to cross-border atmospheric pollution and environmental changes, there is a list of serious factors affecting the conservation and the utilization of forests genetic resources. This includes intensive management in past, artificial regeneration with extensive transfer of forest reproductive material, the reduced size of the population, which is all due to the fragmentation of forests and the introduction of alien species of forest trees. These often lead to the entire loss, or partial change of the genetic identity of indigenous tree populations.

Even though the conservation goal of forest genetic resources can be easily explained, its implementation can be very complex and expensive. The essence of genetic resources and conservation practice is dynamic. Therefore, the conservation of these resources should be seen as an attempt to preserve certain groups of genotypes or populations and their different gene combinations. The goal of genetic resource management is to maintain the conditions in which the genetic structure of species can continue to evolve in response to changes happening in their environment. The main problem in achieving conservation goals is the lack of adequate institutional and policy framework that would consider the possibility of land use and operational management, adopting the framework which would be fair to all interested parties and which can be effectively implemented, monitored and regularly adapted to new needs. Decisions on the conservation process of forest genetic resources should not be taken in isolation, but as an integral part of national development plans and national conservation programs.

Since it is neither feasible nor desirable to isolate large "unmanaged" nature reserves in most parts of Europe, the conservation of forest genetic resources - integrated into recognized sustainable forest management - is urgently needed. The key to success lies in developing those programs which tend to harmonize the conservation process and the sustainable utilization of biological diversity, as well as forest genetic resources in a wide range of possibilities of the land use. The sustainability of these activities will be based on a genuine effort to meet the needs and aspirations of all stakeholders. This will require close co-operation, dialogue and involvement of stakeholders in the planning process and execution of closely related programs. When designing this Program, the Working Group followed the guidelines for the development of the Program of forest genetic resources conservation published by FAO and other organizations (FAO, DFSC, IPGRI 2001; FAO, FLD, IPGRI. 2004a 2004b) and the guidelines that are harmonized with interested parties and adopted at workshops and discussions.

1.1. The Program of genetic resources for agricultural species in Republic of Srpska

At the beginning of this century, witihn the region of Southeastern Europe and the territory of Bosnia and Herzegovina (B&H), the activities on the conservation and sustainable utilization of plant genetic resources, were initiated in accordance with the CBD, FAO and IBPGR. Accordingly, with the financial support from SIDA, an initiative for the preservation and the sustainable utilization of genetic resources of agricultural and horticultural plants was established in B&H. One of the main activities of the SEEDNet project is to establish a national program for the conservation of plant genetic resources. Ever since 2005 the Republic of Srpska Government has allocated specific funds for the maintenance of plant genetic resources, in order to support the project activities and to establish the Program for conservation of the plant genetic resources in Republic of Srpska (Program). The Program entered the agenda of the National

Assembly of Republic of Srpska in 2006. By the decision No. 01-33-950/07 made on 16 February 2007 by the Minister of Agriculture, Forestry and Water Management, a working group was established to develop the Program for the conservation of plant genetic resources in Republic of Srpska was established. The National Assembly of Republic of Srpska adopted "*The* p*rogramme for conservation of plant genetic resources of the Republic of Srpska*" in June 2008, and provided a legal framework for the implementation of activities for the protection and the sustainable utilization of plant genetic resources. The decision for this Program to come into effect was published on June 24th, 2008 in the "Official Gazette of Republic of Srpska" No. 59/08. This Program defined that a new organizational unit of the University of Banja Luka – Institute for Genetic Resources will be in charge for its realization. As stated in the Agreement between the Ministry of Agriculture, Forestry and Water Management and the University of Banja Luka, the Institute is responsible for all activities regarding the program implementation and reporting activities (annual reports to the Government and every three years to the Republic of Srpska National Assembly).

However, the approved **"Program for Conservation of Plant Genetic Resources of the Republic of Srpska"**, **did not cover forest genetic resources**, even though forests cover about 49% of the Republic of Srpska land (NEAP, 2003) (according to unofficial data from the second forest inventory this percentage is much higher). By the decision No. 01-33-7992/10 made on May 24th 2010 by the Minister of Agriculture, Forestry and Water Management, a new Working Group was appointed to make the draft version of the Program of forest genetic resources conservation. The group consist of: Prof. Milan Mataruga, Prof. Vasilije Isajev, Prof. Saša Orlović, Prof. Gordana Đurić, MSc. Jugoslav Brujić, MSc. Vanja Daničić, MSc. Branislav Cvjetković, BSc. Mira Ćopić, MSc. Pero Balotić.

There are significant differences in the relevance and balance when it comes to the application of strategies and, more specifically, the methods for the conservation and management of agricultural crops and forest genetic resources. Long-lived tree species are genetically the most variable organisms on Earth. The objectives of forest genetic resources management significantly differ from the objectives of genetic resource for agriculture species, which is due to the longer cultivation cycle. Environmental variability of conditions in forested areas and within individual forest population is the source of many variations and broad scope of these variables. The time scale in which these conditions vary differs a lot – from a few days to a few decades, usually providing a situation with a large number of different species of long life cycles. The conservation process of forest genetic resources involves the conservation and the sustainable utilization of the existing and largely self-renewable resources, made up of populations that have undergone only minor selection activities by man. Forest management has a wide range of different purposes. Wild populations are dynamically changing within time and space, both in terms of their genetic and species (interspecific) structure. The large level of variability that occurs within species provides goods and services that are usually sought from forests. The general forestry philosophy implies the need to establish national programs for forest genetic resources conservation, accompanied with reasonable grounds to establish gene banks and breeding programs, and the use of standard cultivars and varieties, as is often the case in agriculture (FAO, FLD, IPGRI, 2004a, b).

2. LEGAL FRAMEWORK FOR THE DESIGN OF THE PROGRAM OF FOREST GENETIC RESOURCES CONSERVATION

The constitutional basis for the adoption of the Program of conservation and utilization of forest genetic resources in Republic of Srpska contained in Article No.64 of the Republic of Srpska Constitution stipulates that "the Republic will protect and promote: the rational utilization of natural resources in order to protect and enhance the quality of life and to protect and restore the environment in the public interest ...", while the Amendment XXXII, which replaced the Article No. 68 of the Constitution, stipulates that "the Republic will regulate and ensure: ... 8) basic objectives of economic, scientific, technological, demographic and social development, agricultural and rural development, use of space, policies and measures to guide the development and commodities; ... 13) environmental protection; ".

2.1. International regulations at global level

FAO has a long tradition of dealing with genetic resources research work, particularly its Department of Forestry. Throughout its Program of forest genetic resources, FAO advises governments and national institutions about strategies for genetic conservation and their relations with broader issues of forest management and conservation of biological diversity, supporting institutional and capacity strengthening, providing technical support to the management of forest genetic resources, including their conservation, enhancement and sustainable utilization. FAO has established the Panel of experts on forest genetic resources in 1968. FAO Panel directly and indirectly provides suggestions about the programs and priorities in the field of forest genetic resources.

FAO Conference (through the Resolution 3/2001) adopted an international treaty on plant genetic resources for food and agriculture in November 2001 *(FAO International Treaty on Plant Genetic Resources for Food and Agriculture*). This is a legally binding agreement that covers all relevant plant genetic resources for food and agriculture (including tree species such as poplar and willow). The agreement is in line with the Convention on Biological Diversity.

The International Plant Genetic Resources Institute (IPGRI) has its roots in the International Board for Plant Genetic Resources (IBPGR), founded in 1974 by the Consultative Group on International Agricultural Research (CGIAR). IBPGR became independent CGIAR center in 1994 under the name of IPGRI (The International Plant Genetic Resources Institute). IPGRI maintains close relations with FAO through the Memorandum of Understanding.

The cornerstone of all future efforts to develop the principles of environmental protection was the United Nations Conference on the Human Environment (UNCHE), held in 1972 in Stockholm. The main decision was to establish the balance between environmental and socio-economic development.

United Nations Conference on Environment and Development (UNCED), Rio de Janeiro 1992, defined the concept of sustainable development as "the development that meets the present time needs without compromising any of the capacities which might prevent future generations to meet their own needs". This conference adopted the following documents: the Declaration on Environment and Development, Agenda 21, the Convention on Climate Change, the Convention on Biological Diversity, Principles of management, conservation and sustainable development of all forest types. The Convention on Biological Diversity (UN CBD) as the most important aspect of forest genetic resources was the first ever signed document which is related to the conservation of biological diversity at all levels: genetic, species and ecosystem. It came into effect on 29th December 1993. The main objectives of this Convention, which are to be pursued in accordance with its relevant provisions, are the conservation of biological diversity, the sustainable utilization of its components and the fair distribution of the benefits arising from the utilization of genetic resources in a manner that includes appropriate access to genetic resources and the transfer of relevant technologies, taking into account property rights over those resources and technologies, as well as the appropriate financial support. As stated in the CBD, each country is responsible to provide a rational conservation and sustainable utilization of plant genetic resources. These powers and responsibilities are usually delegated to gene banks and **implemented through national programs**, including cooperation with other official institutions and other relevant stakeholders in the country.

The World Summit on Sustainable Development (WSSD) held in Johannesburg in 2002, put the focus on five key elements: water, energy, health, agriculture and biodiversity.

One of the first areas related to forest genetic resources, which is regulated by international law, is an exchange of forest reproductive material in the functional trade. The proper use of materials for reforestation and restoration is the basis of sustainable forest management, including the conservation of genetic resources. Although the long-term consequences of the resources transfer are still considered as marginal, the importance of origin, quality and diversity of seed sources for the adaptation and the offspring growth have widely been recognized. Consequently, the first OECD scheme for the certification of forest reproductive material which circulates in international trade (OECD Scheme) was adopted in 1966. Activities such as the progress of forest genetics and tree breeding, as well as the growing environmental concerns and the enlargement of the European Union since 1966, brought about the new Directive (1999/105/EC) adopted by the Council of European Union at the end of 1999. The current version has been in force since 2006. The scheme is a global reference standard consisting of 7 rules which are to guarantee the identity and the quality of forest reproductive material. Attention was also paid to the quality and the preservation of resources of forest reproductive material. There are 25 member countries to this scheme, including OECD members and non-members (eg, Romania, Serbia, Croatia, and Turkey). With regard to the new EU member states such as Romania, Hungary and Slovakia, the OECD membership scheme helped them get in line with the EU system for forest reproductive material. The OECD membership scheme enables non-EU countries to have the status of "equivalent third countries" in terms of the trade in forest reproductive material. The scheme is also used as a reference to the Law on forest reproductive material in countries like Japan, South Korea, China, Brazil, and several other African countries.

The new directive and the proposed OECD scheme reflects the current state of forest genetics and tree breeding, increasing public awareness on environmental issues, as well. It promotes international cooperation of national authorities throughout the exchange of relevant information. The Directive was transposed into each Member States' national law and therefore each EU member state has its own official national body for forest reproductive material. Entities within the European Commission which coordinate activities within this area are the Directorate General for Health and Consumers (DG SANCO) and the Committee on propagating material in agriculture, horticulture and forestry. The new Directive of the European Commission under Article 5 refers to the specific directive 90/220/EEC of genetically modified organisms, especially on the environmental risk assessment. The GMO directive was revised and renewed by Directive 2001/18/EC.

Additionally, the international cooperation within the conservation process and sustainable utilization of genetic resources in agriculture, horticulture and forestry is supported by the Program of the conservation, characterization, collection and utilization of genetic resources in agriculture (AGRIGENRES). This program is a co-financed project EUFGIS - setting up a European information system for forest genetic resources.

Another area covered by international legal framework regards the access and sharing the benefits related to the exchange and the utilization of genetic resources. The overall international environmental policy in this area has undergone significant events and changes over the last ten years (2000-2010).

The following international provisions within the legal and policy framework which are directly or indirectly related to forest genetic resources are also significant:

- International Plant Protection Convention, Rome, 1951 (IPPC);
- Convention on Wetlands of International Importance especially as Waterfowl Habitat, Ramsar Convention in 1971;
- Convention on the Establishment of the Organization for the Protection of European and Mediterranean plants (EPPO);
- Berne Convention, 1979, Convention on the conservation of flora and fauna in Europe and natural habitats;
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1976;
- International Convention for the Protection of New Varieties of Plants (UPOV);
- The contract of membership in the International Association for Seed Testing (ISTA);
- Agreement on Trade in Intellectual Property Rights (TRIPS);

- World Organization for Intellectual Property Organization (WIPO);
- Cartagena Protocol on Biosafety of the Convention on Biological Diversity, 2000;

2.2. International regulations at European level

The key events and the driving forces to preserve forest genetic resources were the Ministerial Conferences on the Protection of Forests in Europe. The first conference was held in Strasbourg, France in 1990, when six resolutions were passed and the second one was **"S2"-Conservation of Forest Genetic Resources.** The second Ministerial Conference in Helsinki reflected common European attitudes towards the promotion of sustainable forest management (SFM), the conservation of biological diversity, strategies regarding the possible consequences of climate change in the forestry sector and the greater cooperation among countries in transition towards market economies. The second resolution, **"H2"-General Guidelines for the Conservation of Forest Biodiversity in Europe** is to be highlighted**.** The Third Ministerial Conference, held in Lisbon in June 1998, focused on the socio-economic aspects of forests and the relationships and interactions between the forest sector and society. The conference defined four objectives: biodiversity conservation and the corresponding improvement in sustainable forest management; proper preservation of all forest types in Europe; define the role of forest ecosystems to improve landscape diversity, and specify the activities of other sectors on forest biological diversity. At the Fourth Ministerial Conference on the Protection of Forests in Europe, held 2003 in Vienna, five resolutions were passed, the fourth one is to be highlighted **"V4" - Conservation and Enhancement of Biological Diversity of Forests in Europe.** The Fifth Ministerial Conference entitled "Forests for the quality of life" was held in Warsaw in 2007, when two resolutions were defined: W1 - Forests, Wood and Energy and W2 - Forests and water. At the Sixth Ministerial Conference held in Oslo, Norway, 14-16 June 2011, it was agreed that European forests were critical in settling climate change and in activities promoting the green economy. Those political decisions which aimed to preserve forests and protect their economic, environmental and social benefits were in the focus of this conference.

The main international legal and policy framework for forest genetic resources in Europe is within the EUFORGEN. The European Forest Genetic Resources Programme (EUFORGEN) has been in practice since October 1994, acting as a common mechanism among European countries to promote the conservation and the sustainable utilization of forest genetic resources. EUFORGEN was established in order to implement Resolution 2, "Conservation of forest genetic resources," passed at the first Ministerial Conference on the Protection of Forests in Europe. Among the first steps the EUFORGEN network undertook was to develop long-term strategies for the conservation of genetic resources of species or groups of species of high priority. The main aim of the strategy is to provide an evolutionary adaptive potential of European forest tree species. Even though *in situ* conservation efforts provide the first priority, it is suggested that *in situ* and *ex situ* protection measures are to be used in a complementary way, in accordance with threats and specific needs of the species intended for genetic conservation. **Bosnia and Herzegovina is one of the few European countries which does not have an official representative within the EUFORGEN, nor is its member.** Activities of the European programs undergo the following phases:

Phase I (1994 - 1999). The activities started with four pilot networks which focused on the dark poplar, oak Mediterranean, noble deciduous and spruce. The fifth network of sawmills which formed stands was established in 1997.

Phase II (2000 - 2004). During the second phase EUFORGEN continued its work through the network. The network of spruce expanded and changed its name to the Conifer network. Similarly, the network of cork oak tree changed into the network of Mediterranean oaks. The network of social broadleaves changed its name into the network of oak and beech species of temperate regions in 2002. By December 2004 the EUFORGEN had 32 members.

Phase III (2005 - 2009). During the third phase, the Supervisory Board reorganized the structure of the network, and the five networks merged into three: the network of conifers, the network of broadleaves which did not form stands and the network of broadleaves which formed stands. It established a new network of forest management, also.

Phase IV (2010 - 2014). The fourth phase of the program began on 1st January 2010, and it will last til 31st December 2014. In the fourth phase the EUFORGEN activities will primarily focus on climate change, the appropriate use of forest genetic resources in the light of climate change and their impact on forest management, particularly the utilization of forest reproductive material, as well as the conservation of forest genetic resources.

Other relevant strategies and regulations applied in Europe or at the EU level are:

• The Habitats Directive - Council Directive 92/43/EEC of 21st May 1992, on the conservation of natural habitats and wild flora and fauna;

• European Biodiversity Strategy adopted in 1998, and

• Forest Strategy for the European Union adopted in 1998.

2.3. The options of international cooperation through the program of forest genetic resources conservation

Once the conservation programs have been created and the utilization of forest genetic resources has been targeted, the possibility of international cooperation and the establishment of clear communication will open up through the following activities:

• Transfer of forest reproductive material for the purpose of monitoring the effects of climate change on the utilization of forest reproductive material.

• Comparative analysis of different European provenance regions for certain tree species.

• Define guidelines for the utilization of reproductive material in different altitudinal belts.

• Monitoring the periodicity and the abundance of flowering process and the harvest of forest tree species in different climatic, edaphic and geographical conditions.

• Technical guidelines for genetic conservation of species.

• A study of vulnerability and loss of species (biodiversity loss) and its causes; the vulnerability of native species by invasive species.

• Determine the optimal forest cover.

• Preserve the quality of forest seed in the process of processing and storage activities.

• Develop standards for forest seedlings.

2.4. Domestic regulations

In accordance with the Article 6a of the Convention on Biological Diversity, Bosnia and Herzegovina implemented the project "*National Strategy and Action Plan for the Protection of Biological and Landscape Diversity of B&H*" accompanied with an action plan for the conservation of biological and landscape diversity (2008-2015). The study of biological and landscape diversity "Bosnia and Herzegovina - Land of Diversity", which is in the same time the country's first national report according to the Convention, served as a basis to adopt the Strategy. The project was initiated in January 2006 by the Ministry of Physical Planning and Environment, and continued through the Ministry of Environment and Tourism in Federation of Bosnia and Herzegovina. The project pointed out that there is a high degree of gene diversity and genetic resources in B&H which deserve more attention than they get. Prominent traditional biotechnologies are to be put into operation in order to facilitate the development of a country, and thus to preserve the traditional knowledge and practices, as well as indigenous gene pool present in B&H.

The policy of protection and conservation of natural environment in B&H is delegated to the entities. The Republic of Srpska has its Law on Environmental Protection - Revised text of "**The** Official Gazette of the Republic of Srpska" No. 113/08. Among other things, this law regulates the restoration, protection, conservation and sustainable development of landscapes, natural areas, plants, animals and their habitats, soil, minerals, fossils and other natural components, which are part of the environment, in the manner and under the conditions set by this law. The main objectives of the Law focus on creating the conditions for conservation activities and sustainable development of nature and the environment via restoration, protection, conservation and sustainable utilization of ecological balance in nature, as well as the reduction of the utilization and pollution of species (animals, plants, fungi). The Law on the nature protection through its definitions of "biological" and "genetic diversity" gets in touch with forest genetic resources. The Article 26 of this Law defines the categories of protected areas, while the Article 28 defines management goals of protected natural areas emphasizing "the maintenance of genetic resources in a dynamic and capable development." The Nature Protection Strategy which sets out a series of measures to strengthen the awareness of the need for environmental protection in Republic of Srpska was adopted In

2011 ("Official Gazette of the Republic of Srpska" No. 65/11).

The Law on Environmental Protection - revised text ("Official Gazette of the Republic of Srpska" No. 28/07, 41/08, 29/10) among other things regulates the conservation, protection, restoration and improvement of environmental quality, the environment capacity and the quality of life, as well.

When creating conservation programs for forest genetic resources, the domestic legislation has its base in the **Law on Forests** ("Official Gazette of the Republic of Srpska", No. 75/08). Pursuant to this Law under the Article 5, the conservation and the development of forest genetic resources is defined in terms of the public interest. Moreover, the protection of genetic resources and the production of forest seeds and seedlings are regulated by the Article 6. The production of forest reproductive material is defined in Articles 66, 67 and 68 of the Law on Forest. Additionally, the Law on Forests in the Article 95 anticipates the possibility of using allocated funds in order to preserve, enhance and direct the biodiversity utilization in forest ecosystems.

Forestry Development Strategy (adopted in 2012) defines and highlights the need for conservation of forest genetic resources in the Republic of Srpska, also.

However, the greatest emphasis on forest genetic resources is put by the **Law on forest reproductive material** ("Official Gazette of the Republic Srpska", No. 60/09). The law defines and regulates the basic features of the initial and the reproductive material of forest trees, conditions, methods to assess and recognize the initial material, production, inspection and treatment of reproductive material of forest trees, as well as its quality, sale and use, and the act of keeping a register of forest sorts and other registers. The Law by its Article 6 in Paragraph 2, defines the necessity to establish a genetic bank of forest plants in order to preserve genetic diversity and its sources. Additionally, the paragraph 4 of the same article, stipulates the implementation of activities defined by paragraphs 2 and 3 in accordance with the existing **"Conservation programs of plant genetic resources"**. The fact that the program did not include forest genetic resources, initiated the creation of the Program of forest genetic resources conservation. The Law by its Article 10 in Paragraph 1 defines the manner of establishing provenance regions for the production of source material of recognized origins and breeding materials. The law defines the ways to recognize the source material, keep the register, as well as how the production, supervision, refinement, quality, trade and the use of reproductive material will be carried out.

Pursuant to this Law, the following regulations were adopted:

a) Regulations referring to the list of tree species, hybrids and cultivars which are employed in deriving the reproductive material ("Official Gazette of Republic of Srpska", No. 105/09)

b) Regulations referring to the act of establishing genetic banks of forest products ("Official Gazette of Republic of Srpska", No. 107/09)

c) Regulations referring to the manner, procedure and conditions to evaluate and recognize the reproductive material of forest trees ("Official Gazette of the Republic of Srpska", No. 8/10)

d) Regulations referring to the Register of Forest Sorts ("Official Gazette of Republic of Srpska", No. 111/09)

d) Regulations referring to of the production, processing and supervision of forest tree reproductive material ("Official Gazette of Republic of Srpska", 4/10) and

f) Regulations referring to the quality, trade and the use of forest tree reproductive material ("Official Gazette of Republic of Srpska", 4/10).

3. THE MAGNITUDE AND OBJECTIVES OF THE FOREST GENETIC RESOURCES CONSERVATION

Forests are the most biologically diverse ecosystems on earth since they are among the richest terrestrial ecosystems. Beside their capacity to provide habitats for many plants and animal species, they also possess a set of abiotic key features. For example, forests act as an essential buffer of climate change. Forests are an important factor in the circulation of water in the atmosphere. Furthermore, they regulate the water regime by increasing the infiltration and reducing the runoff and flood protection, consequently affectinng the amount of water, which is essential when it comes to the water supply of streams in a mountain area. Forest ecosystems are the best natural biofilter as they play a critical role in protecting and improving the water quality. Water scarcity is certain if we bear in mind that the planetary water reserves of fresh water are merely 2.86% and those available to man only 0.62%.

The influence of forest ecosystems in land creation is invaluable, moreover it should not be neglected that forests play a crucial role in the improvement of land productivity, land protection within other ecosystems and in the reclamation process of degraded areas. In relation to the land protection forests prevent erosion, landslides and the emergence of wetlands.

The status of forest genetic resources in the world and in B&H implies how important they are for the landscape where they have a key role. If we add to this the aesthetic value of forest complexes and their multipurpose capacities, then it is reasonable to suggest that forests are of a primary value for ttheir scenery, i.e. the landscape. Forests should, not only by their existence, but through their significant role, also, impose its influence to others, especially to cultural contents which man creates in a natural environment. At the same time, forests play significant economic, social and cultural roles. In contrast to the agricultural and horticultural plants, the forests in Republic of Srpska primarily consist of natural populations that are of a greater or lesser influence to man. However, the natural geographical distribution of genetic resources can be significantly altered by human influence (the intensity of the harvest, selection criteria for tree logging, the transfer of reproductive material, etc.) in an extent that will depend on the intensity of human activities.

The loss of genetic diversity is an issue which is frequently addressed to in contemporary society, however, its long-term importance for human well-being has not always been recognized. In order to ensure better use of existing resources, and to reduce the negative impact of genetic impoverishment in the woods, there is a need for sound management and conservation of their genetic resources. Over the past fifteen years, increased attention has been drawn to the activities of conservation and directed utilization of plant genetic resources.

Genetic diversity is an integral part of biodiversity, which is differentiated into three levels: a) the diversity of ecosystems, b) species diversity and c) diversity within species (genetic diversity). The diversity between individuals of the same species is in fact the genetic diversity that allows species to adapt to changes in their environment. Thus, although immaterial, and often invaluable, genetic diversity is of a vital importance for the present and future well-being of forest ecosystems, forestry and industry in general. In short, it is of vital importance for the future of forests at global and local levels.

Genetic diversity is the basic unit of biodiversity. The features of forest tree species vary within the range of species due to the adaptation to specific environmental conditions. Therefore, in terms of adaptation each local population represents a unique genetic resource. The loss of population is sometimes called the "silent extinction" since the species have not become extinct, but their valuable genetic resources are lost and cannot be easily or quickly restored.

Genetic diversity is a prerequisite for the evolution. This is the basis for flexibility and thus the survival of the species. Forest trees are usually among the long-lived, highly heterozygous organisms which have developed natural mechanisms to maintain a high level of variation within the species. This diversity, which resulted in a unique and irreplaceable framework of forest genetic resources, enables forests and trees to adapt to changes and adverse conditions for thousands of years. Some of these mechanisms are manifested by high crossbreeding rates of species which are not closely related and by the dispersal of pollen and seeds over a wider area. Conservation and directed utilization of forest genetic resources undertake series of actions and measures to ensure the continuation of life, evolution and availability of these resources for present and future generations. Genetic diversity ensures that forest trees survive, adapt and develop under variable conditions. In addition, forest genetic diversity plays a key role in maintaining forest biodiversity at the level of ecosystems, species and populations. Genetic diversity, namely the diversity at intraspecific level, is a critical component of biological diversity because it allows species to evolve over time and space, and thus plays a key role in the long-term survival.

Forest genetic resources have provided the capacity to adapt in the past, and will continue to provide this vital role in the challenge of mitigation or adaptation as the climate change continues. Keeping in mind the aspects of the current climate change, it can be assumed that the growing conditions in 100 years will not be the same as they are today and that the adaptability over a long period of rotation will be important when considering the management of forest ecosystems. Trees have different mechanisms for natural seed dispersal which allow trees to migrate to long distances. However, for many species which possess this important feature may not be enough to survive today's rapidly changing climate zone.

Genetic diversity is required also to maintain the forest fitness and to deal with pests and diseases.

Genetic diversity ensures that the needs of future generations are met. This is especially true when the demands for supply of raw material (wood) must at least be met and under varying conditions. For this reason genetic diversity is the basis for sustainable, efficient and multifunctional forestry. At the same time it serves as a basis for genetic improvement of the breeding process.

Forest genetic resources possess significant economic values: current, as well as the potential ones. For example, genes are resources of the tree quality improvement and of the source material which enhances the growth rates of commercial tree species, as well as, provide the capacity to develop resistance to pests, drought, high and low temperatures, etc. Therefore, genetic resources are vital for the sustainable management of forest resources, and thus for the wood industry.

Their economic value is represented by new products which will come from the forest in the future, including medical and other non-timber forest products. Development and sale of such products will strengthen the rural economy and provide the health benefits to the human population.

Forest resources are generally controlled and managed by long rotation periods (the period between regeneration and harvesting), 5-20 years for plantations, and 150-170 years for natural oak forests. In the course of developing the sustainable forest management, it will be necessary to implement forestry practices to maintain genetic diversity over longer period. Sustainable forest management requires a better understanding of the specificities of forest trees and their genetic diversity. Forests provide a wide range of products, socio-economic benefits and environmental protection. Sustainable forest management aims to manage forests in a way in which forests will provide benefits to human well-being preventing them to diminish over time. Such conservation and proper utilization of forest genetic resources is an important element of sustainable forest management.

Sustainable utilization of forest genetic resources, including the appropriate selection of forest seeds and germplasm management, provides the basis for the establishment of new forests and plantations. The right choice of species and seed sources, in line with site conditions at the site, combined with proper breeding measures can improve productivity for more than 20%.

In breeding activities, forestry experts can develop and use a high level of genetic variation, which is present within several species. Since crop breeders and farmers often substantially alter the environment to suit the specific crops and varieties growers, they often identify species and provenances which can provide better products and services without extensive management or extensive modification of the environment. Therefore, the production systems in forestry and agroforestry largely depend on the continuous availability of these different genetic resources at both the species and at the level of origin (of the population). Genetic variations within species are necessary for their adjustment in the future, as well as for the artificial selection and breeding programs. Accordingly, a man will benefit from forests and trees if forest genetic resources remain available.

Activities of monitoring the diversity of populations in natural forests can improve our understanding of how ecosystems work. Intensive genetic selection and breeding activities are carried out for plantation forestry and agroforestry system needs. However, the vast majority of forest genetic diversity remains unknown. The estimated number of species range from 80,000 to 100,000, but less than 500 were assessed in terms of their current and future potential. Until recently, studies of genetic resources of forest trees have focused on the domestication process of the few important traits which are most frequently used in the production of wood, fiber, and fuel production in plantations and agroforestry system.

Finally, bearing in mind our responsibility to future generations, genetic diversity must be preserved for ethical reasons in order to preserve the ecosystem, species and populations in their variety and in undamaged condition. Our commitment is to "preserve what we have inherited from our ancestors for generations to come". United Nations Economic Commission for Europe estimates that the demand in the future can be met without depleting our forests. Particularly sensitive ecosystems are threatened in the long run. Since the area of the Balkan Peninsula is known as a resource of glacial diversity, the genetic diversity is present in many tree species (Hewitt, 1999, Petit et al. 2003,) making it of a high importance for the process of forest genetic resources conservation.

4. THE CURRENT SITUATION OF FOREST GENETIC RESOURCES IN REPUBLIC OF SRPSKA

Republic of Srpska is among the areas with the highest levels of biodiversity in Europe. On the basis of existing inventory, it is clear that the flora and fauna, ecosystems and biodiversity are highly abundant and, if compared to the corresponding abundance of species groups, i.e. biocenosis and ecosystems within the Balkan Peninsula and Europe, this abundance is not only a matter of a national treasure, but of an extraordinary potential, also. In this region Bosnia and Herzegovina and Republic of Srpska are among the countries with the richest diversity of domesticated wild plants and animals throughout the long history of civilization. Some of them became so common and well-adapted that together with wild forms they present a valuable part of the natural heritage (information taken from the report of Bosnia and Herzegovina for the World Summit on Sustainable Development).

The specific geographical position on the line where Central European and Mediterranean influences collide, the turbulent geo-tectonic dynamics and the diversity of geological, hydrological, climatic and soil characteristics have all influenced the Republic of Srpska to be an area of exceptional genetic, species and ecosystem diversity.

On the territory of the Republic of Srpska there are primary gen-centers for the number of endemic and endemic-relict species, and the first one to be highlighted here is Serbian spruce (*Picea* *omorika* Pančić/Purk). Forest resources of the Republic of Srpska are rich in ecotypes, varieties, forms and other forms of polymorphisms, which are significant factors in the process of preservation the adaptation capacity of species (Tucović and Isajev 1997; Isajev et al. 1997; Mataruga, et al. 2000a; 2005).

The starting point for any research work, protection activities and the directed utilization of the biodiversity of protected areas in Bosnia and Herzegovina, is an Ecological and vegetation regionalization of Bosnia and Herzegovina (Stefanović et al. 1983), in which its territory is divided into four areas, with 14 regions: **Pannonian area** with the regions of: 1.North Bosnian, 2.Northwest Bosnia; **Transitional Illyrian and Moesian area** with regions: 1.Lower Drina river, 2.Upper Drina river; **Internal Dinarides area** with regions: 1.Cazin, 2.West Bosnian limestone and dolomite, 3.Central Bosnian, 4.Zavidovićko-Teslićko, 5.East Bosnian highlands, 6.Southeast Bosnian; **Mediterranean area** with fields: 1.Sub-Mediterranean and mountains, 2.Sub-Mediterranean Mountain, 3.Sub-Mediterranean and 4.Eumediterranean.

The natural heritage of Republic of Srpska (Bosnia and Herzegovina) is remarkably valuable. This category includes: national parks, natural areas of restricted space, individual plants and animal species, natural monuments and protected areas. About 1% of the total area of forests and forest land in Republic of Srpska comprises of virgin forests, national parks, natural monuments, protected landscapes and reserves. According to other data only 0.55% of the territory is under the official protection (compared to the EU countries with an average of 7%). Currently, there are only two national parks National Park “Sutjeska” and National Park “Kozara”, as well as the virgin forests “Perućica” within the National Park "Sutjeska," “Janj” and “Lom”. However, we should not neglect the fact that the significant areas of forests found in the extreme orographic-edaphic conditions (gorges, canyons, etc.) outside the forest management, are special resources of biodiversity and genetic resources. There is an option to extend the area of protected forests and forests of special purposes by at least 5% of the total area.

Flora of Bosnia and Herzegovina counts 4.500 higher plant species, 600 moss taxa and about 80 fern taxa (Brujić, J 2011). There are currently about 250 species of forest trees and shrubs. Over 200 species of fauna can be found in forests, also.

There are 449 taxa (species and subspecies) of higher plants and 79 endemic species registered (Ratknić et al. 2006) in the virgin forest “Perucica”. As far as the National Park "Kozara" is concerned, with its total area of 3.494 ha, the number of 865 registered species comprises 117 fungi, 11 lichens, 80 mosses and 657 species of higher plants (Bucalo et al. 2007). The primeval forest of Lom, covering the area of 298 hectares, counts 463 species consisting of 74 fungi, 37 lichens, 96 mosses and 256 vascular plants (Bucalo et al. 2008). These are only some of the examples of the huge diversity of species that can be found within a relatively small area of forest ecosystems.

4.1. The effects of the sustainable forest management on forest genetic resources

Forest management in Republic of Srpska employs “the principle of sustainability” in order to support the sustainability of forest communities and ensure their protection. The management system promotes the natural regeneration of forests providing the intraspecific diversity and the protection of forest values. This scientific approach is generally accepted and is an integrated part of the traditional forest management practice. The system is developed in detail and incorporated into each management plan. The concept of forest management on the territory of Republic Srpska has a long tradition (it has developed for more than 100 years) and it is generally in line with international criteria for sustainable forest management and biodiversity conservation.

The greatest number of forests in Republic of Srpska falls within public forest owned by the PFE "Forests of the Republic Srpska” a.d. Sokolac (Table 1). Bearing in mind the fact that about 75% of forests are in the ownership of the Republic it can be concluded that this ownership structure (large influence of stakeholders, local communities, the possibility of vertical hierarchical structure) may be suitable for the implementation of plans which aim to preserve forest genetic resources. PFE "Forests of the Republic Srpska” has received FSC certification for forest management, implying that forests and forest lands are managed according to strict environmental, social and economic standards, which partially includes the aspect of forest genetic resources conservation.

Table 1. Area of forests and forest land in the Republic of Srpska by category of property

No	Property category	Property Area / ha /	Percentage /% /
1.	State forests	982.468 ,00	74,7
2.	Maintain (formerly usurped state forests)	17.972,00	1,4
3.	Private forests	291.877,00	22,2
4.	“Industrial plantations” a.d. Banja Luka	7.500,00	0,6
5.	National park "Kozara"	3.530,03	0,3
6.	National park "Sutjeska"	10.484,88	0,8
	Total	1.313.831,91	100,00

Source: Information on the situation in forestry in the Republic of Srpska, November, 2011.

Table 2. The overview of forests and forest land in Republic of Srpska

Forests and forest land	State		Private		National Parks		Total	
	ha	%	ha	%	ha	%	ha	%
High forest with natural regeneration	456.674		66.636		10.673		540.483	42
High degraded forests	24.752		7.763		643		33.358	2.6
Planted forests	61.608		887		390		68.885	5.4
High forests - total	543.034	55	77.286	28	11.906	84	642.726	50
Coppice forests - total	170.811	15	181.056	65	833	6	354.454	28

Bare land suitable for afforestation	194.505		13.128		216		207.849	16
Bare land unsuitable for afforestation	64.770		5.631		1.277		71.678	
Total – bare land	259.275	27	18.759	7	1.493	10	279.527	22
Total – forests	713.845	73	258.342	93	12.739	90	997.180	78
Total forest land and bare land	259.275	27	18.759	7	1.493	10	279.527	22
Total	**973.120**	**100**	**277.101**	**100**	**14.232**	**100**	**1.276.707**	**100**

Source: The strategy for Nature Protection of the Republic of Srpska

High forest with natural regeneration is the dominant category in the Republic. They account for 47.1% of the total area. They are followed by the areas suitable for afforestation with 21%, young forests with 18%, planted forests with 6.2% and the areas unsuitable for afforestation with 5.3%, while the least represented are high degraded forests with 2.4% of the area. Unlike the forests owned by the Republic, the most common category owned by private forests is coppice forests which cover the area of 63.2%. Directly after come high economic forests with 32.9%, then there is an area suitable for afforestation with 2.3%, high degraded forests by 0.8%, while the least represented are areas unsuitable for afforestation and planted forests with 0.4%.

4.1.1. Management of natural regeneration forests

Beech prevails in high forests of natural regeneration, while forests of beech, fir and spruce and fir with spruce (40% of the total area of forests owned by the Republic) are also represented but not in a such high number. (Forest Strategy, 2012). Combined methods of regeneration which employ the “selective” management system are applied in these forests. The group selection cutting system is employed to almost the entire area of high forests in Republic of Srpska leaving enough space for the designer and the contractor to adjust the intensity according to species and habitats (in terms of defining the regeneration core). Since the results of restoring mixed forests are good, the general standpoint approves its continuous application. The production potential of high pure beech and oak forests of natural regeneration has not been exploited in the best way. The general situation of pure and mixed conifer stands is significantly better than it is in pure and mixed deciduous stands. Therefore, in order to fully exploit the production potential of deciduous forests (especially beech and oak) it is necessary to elaborate the management system according to the production types of these forests, i.e. management classes (Forest strategy, 2012).

When woody species are considered useful in the processes of selection and logging, unsustainable patterns of utilization are another threat to genetic resources. This issue usually addresses the intensity and the frequency of tree logging, either for timber or non-timber production purposes, as well as the way forests respond after harvest at species and ecosystem level. Degradation of genetic resources does not necessarily imply the removal of all trees, it can take the form of selective harvest, leaving only trees in poor health for future cycles of reproduction which can affect the quality of seeds and natural regeneration, and consequently influence economic benefits in the long period of time. Selective thinning activities lead to reduction of stands which can cause changes in genetic structure of the remaining population. Intensive selection through tree marking and felling activities may endanger genetic diversity and the quality of offspring if the selection has a "negative sign".

4.1.2. Planted forests and plantations

In Republic of Srpska, there are about 70,000 hectares of planted forests covering 5.4% of the total area under forests, whereas there are not any plantations (according to the definition of the word plantation) (Table 2). Planned activities of thinning in the current management activities are rarely implemented. These categories are not represented in high number in private forests (about 887 hectares only). Areas suitable for afforestation cover 207.849 ha or 16% of the total forest land in Republic of Srpska. In these areas there aren't any species of the economic interest, and therefore it is necessary to perform appropriate afforestation activities. With the help of the "Ministry of agriculture, forestry and water management" in the period 2003-2009, the area of 9.086 ha of the state forest was afforested. Reforestation covered the area of 7,649 ha, or 84%, while afforestaton covered 1.437 ha or 16%. The index of the increased forested area was 1,2. So far financial support has been granted for the afforestation/ reforestation activities in forests owned by the state. Some details regarding the former activities establishing new forests and prospects in the future could be the following:

-a large area of coppice forests which should be partially translated into higher silcvicultural form through direct conversion measures,

-high participation of area suitable for afforestation within the Forest managemet unit "Center for Karst management,

-consider the presence of private forests covering the significant area of land,

-registered seed objects, whereas there aren't any defined provenance regions leaving no possibility to transfer forest reproductive material within the same ecological vegetation area,

-there is neither horizontal nor vertical zonality regarding the utilization of forest reproductive material when establishing new forests,

-the establishment of new forest with conifer species in deciduous habitats,

-due to the lack of local seed it is being imported, which is of dubious origin and quality,

-lack of maintenance (measures of care and protection) of the newly established forests, etc.

4.1.3. HCVF

Forest values (economic, social, environmental) can be of global, regional or local importance, however when some of those values are considered to be extremely important forest can be defined as high conservation value forest (HCVF). This implies that appropriate management activities are to be employed in these forest areas in order to preserve and improve the values.

Any type of forest, high or low, natural or artificial, can potentially be of a high conservation value forest, since they can be selected upon the presence of one or more desired values (for example, plantations composed of the introduced conifer species to supply wood to the sawmills or pulp factories can become HCVF if their recreational or other sociological values become primary). The concept of high conservation value forests is originally developed by the Forest Stewardship Council (FSC) for the certification and was part of the implementation of international conventions on the protection of forests.

Types of high conservation value forests under FSC define the following six categories of high conservation value (HCV):

HCV - 1: Forest areas containing globally, regionally or state significant concentrations of biodiversity

1a: Protected Areas

1b: Endangered species and species at risk

1c: Endemic

1d: Critical temporal use

HCV - 2: Forest areas containing globally, regionally or state significant large landscape level forest

HCV - 3: Forest areas containing ecosystems that are in or contain rare, threatened or endangered ecosystems

HCV - 4: Forest areas that provide basic services of nature in critical situations

4a: Forests critical to water catchments

4b: Forests critical to erosion control

4c: Forests providing barriers to destructive fires

HCV - 5: Forest areas fundamental to meeting basic needs of local communities

HCV - 6: Forest areas critical to local communities’ traditional cultural identity.

PFE "Forests of Republic of Srpska" proposed the area of 44.202,54 ha or 4.5% of the total area of state forests, to be included in the process of certification in line with the FSC standards and proclaimed as forests of high conservation value (Appendix 1). Under the current proposal the largest area of forests falls within HCV-4a - (forests critical to water catchments), 21.042.14 ha, while there are not any individual areas in HCV-categories 2, 3, 5. Under the current proposal, registered seed stands fall within the HCV-1a.

Based on the definitions and functions of forests of high conservation value and their classification, there is no doubt that future actions should pay more attention to the conservation of forest genetic resources through management systems, as well as when allocating new areas.

4.2. Protected areas

The process of nomination, allocation and registration of protected areas in Republic of Srpska is regulated by the Law on Nature Protection - Revised text and the environmental strategy. Activities on the allocation of protected areas largely "overlap" with activities on conservation and utilization of forest genetic resources.

The strategy of "do not touch" is based on the idea to reduce the influence of a man to the lowest possible level. However, there are two reasons why it is difficult to apply this strategy:

• First, the existing network of conserved areas is rarely an example of genetic diversity of tree species in systematic or genetic contexts.

• Second, the strategy shows the best effects only in areas where the conservation status is already very high, i.e. in areas with low population density, and where there is no strong economic interest. Moreover, it is often very difficult to establish strictly protected areas in regions where strong pressure of human population is present.

In the Republic of Srpska the following protected areas are currently allocated and registered:

- Natural Monument "Cave Ljubačevo" - Banja Luka, IUCN categories III, area 45,45 ha. Nature Protection Decision of Ljubacevo cave ("Official Gazette of the Republic of Srpska" No. 36/08)
- Special Nature Reserve "Gromiželj" - Bijeljina, IUCN category Ib, area of 831,33 hectares, decision on previous protection of the Special Nature Reserve "Gromiželj" ("Official Gazette of the Republic of Srpska " No. 81/11)
- Special Nature Reserve "Lisina" – Mrkonjić Grad, IUCN category Ib, area of 560,64 hectares, decision on previous protection of the Special Nature Reserve "Lisina" ("Official Gazette of the Republic of Srpska " No. 85/11)
- Natural Monument "Cave Orlovača" - Pale IUCN categories III, measuring 27,01 ha, Nature Protection Decision Orlovača cave ("Official Gazette of the Republic of Srpska" No. 117/11)
- Natural Monument "Yellow beech" - Kotor Varoš, IUCN categories III, area 0,5 ha, Nature Protection Decision of Yellow beech ("Official Gazette of the Republic of Srpska" No. 30/12),
- Area in charge for Resource Management "University City", - Banja Luka, IUCN category VI of 27,38 ha, Decision on the protection of areas in charge of resource management, "university city" ("Official Gazette of the Republic of Srpska" No. 53/12),
- Natural Monument "Cave Rastuša" – Teslić, IUCN categories III, area 11,39 ha, Nature Protection Decision of Cave Rastuša ("Official Gazette of the Republic of Srpska" No. 87/12),
- Natural Monument "The Pit Ledana" – Ribnik, IUCN categories III, area 28,26 ha, Nature Protection Decision of Pit ledana ("Official Gazette of the Republic of Srpska" No. 93/12),
- Strict Nature Reserve "Virgine forest - Janj" - Šipovo, IUCN categories Ia, area 295 hectares, Decision on the protection of the strict nature reserve "Virgine forest - Janj" ("Official Gazette of the Republic of Srpska" No. 123/12),
- National Park "Sutjeska" - Tjentište, IUCN category II, area 16.052,34 ha, Law on the National Park "Sutjeska" ("Official Gazette of the Republic of Srpska" No. 121/12),
- National Park "Kozara", IUCN category II, area 3.907,54 ha, Law on the National Park "Kozara" ("Official Gazette of the Republic of Srpska" No. 121/12),
- Natural Monument "Vaganska cave" - Šipovo, IUCN categories III, area 12 ha, Nature Protection Decision of Vaganska cave ("Official Gazette of the Republic of Srpska" No. 21/13),
- Natural Monument "Cave Đatlo" - Bileća, IUCN categories III, area 43,42 ha, Nature Protection Decision of Cave Đatlo ("Official Gazette of the Republic of Srpska" No. 35/13),
- Strict Nature Reserve "Virgin forest Lom" Petrovac, IUCN categories Ia, area 297,82 ha, Decision on the protection of the strict nature reserve "virgin forest Lom" ("Official Gazette of the Republic of Srpska", No. 39/13).

4.3. The overview of forest ecosystems and species in terms of urgent

measures for forest genetic resources conservation

According to the available information, the category of endangered species in Bosnia and Herzegovina counts 42% of "endangered or vulnerable," species and 42.3% of "rare and vulnerable" ones when the total number of 678 analyzed species is taken into account (Table 3). Only two species are believed to be extinct. This fact justifies the necessity for taking actions and measures in order to preserve not only species, but interspecies diversity also.

Table 3. The vulnerability category of some plant taxa defined by (IUCN) preliminary Red List of Bosnia and Herzegovina

Category of threat	Number of species	representation%
Extinct (Extinct - "Ex")	2	0,30
Probably extinct (Extinct - "Ex?")	6	0,89
Critically endangered species (Endangered - "E")	42	6,20
Threatened or vulnerable species (Vulnerable - "V")	285	42,04
Rare and potentially endangered species (Rare - "R")	287	42,30
Insufficiently known species (Insufficiently Known - ("K")	54	7,97
There is no category	2	0,30
Total number of species:	678	100,00

Source: Strategy for Nature Protection of the Republic of Srpska

With respect to the FAO guidelines when defining priorities and species of forest ecosystems can be divided into three groups:

- α) species (ecosystems) there are not any measures which can help their conservation
- β) species (ecosystems) that will survive without management measures
- γ) species (ecosystems) that will survive only if they are properly managed.

First, it is important to identify the latter category, and then when it receives priority assign financial support to it (Vane-Wright 1996). Detailed lists of species and ecosystems are given in the attached file (Appendix 3 and 4). These make "preliminary" lists which will eventually be updated and revised, in some cases they will change species categories and ecosystems.

Table 4. Distribution of species according to their priority

	Lichens	Mosses	Ferns	Gymnospermae	Angiospermae	Total
Alpha	5	16	5	6	51	83
Beta	0	5	0	0	50	55
Gamma	**3**	**25**	**0**	**5**	**32**	65
Total	8	46	5	11	133	203

The general overview of the species representation is shown in Table 4. Out of the total of 203 analyzed species, the most represented one is Angiospermae. Keeping in mind that the general practice places emphasis and priority to activities regarding (γ Gama) species, it is obvious that significant number of species in this area will survive only if proper management measures are applied. In order to take the concept of genetic resources conservation seriously, we highlight some species which dependent on human intervention: *Arctostaphylos uva-ursi* (L.) Spreng., *Picea omorika* (Pančić) Purkyne, *Taxus baccata* L., *Betula pubescens* Ehrh., *Corylus* × *colurnoides* C.K.Schneid., *Rhus coriaria* L., *Sorbus* x *semipinata* (Roth) Hedl., *Acer heldreichii* Orph. ex Boiss. subsp. *visianii* K. Maly., *Acer hyrcanum auct. balcan. non* Fisch. & C.A.Mey., *Salix pentandra* L. and many others).

So far more than 200 of forest ecosystems have been analyzed, and it was defined that the third group (γ) - "ecosystems that will survive only if they are properly managed " counted 35, which was 17.5% of the analyzed forest ecosystems (Appendix 3).

4.4. Wild fruits and herbs

Among the hundreds of forest species, particular attention is drawn to wild fruit species. The presence of numerous wild fruit species (*Castanea sativa* Mill; *Cornus mas* L.; *Corylus avellana* L.; *Juglans regia* L.; *Malus silvestris* (L.) Mill. *Prunus avium* L.; *Punica granatum* L.; *Pyrus communis* L.; *Ribes grossularia* L.; *Ribes petraeum* Walf.; *Sorbus aucuparia* L.; *Sorbus domestica* L.; *Sorbus torminalis* (L.) Cr.; *Rubus idaeus* L.; *Rubus* sp. (blackberries) *Vaccinuium myrtillus* L.) are critical for forest genetic resources. They are significant natural resources as they provide inexhaustible gene pool which is extremely important for many reasons. First of all, they are essential natural resources of germplasm for fruit species, specifically, the genetic potential of huge importance for breeding and selection purposes of cultivated fruit trees when creating new varieties and and new substrates. When used used in nursery production, planted wild fruit trees serve as a resource of high-quality seeds in the production of generative bases, therefore for the purposes of modern nurseries, fruit trees are vegetatively propagated and planted into nursery. In addition, wild fruits often bear fruit of high-quality and high nutritional value, and can be used in different ways for human consumption and for industrial processing.

Wild fruits are critical in plant genetic resources as they provide significant genetic potential for selection and breeding purposes. Wild fruit species are important components of biodiversity since they carry genes for resistance to diseases, pests and abiotic stress factors, and therefore act as a source of target traits in breeding varieties and rootstocks in fruit-culture. The fruits of wild fruit trees are typically rich in nutritional values, such as vitamins, antioxidants and minerals. When cultivars originating from wild relatives are used in intensive production in order to provide more food, these properties are usually lost or significantly reduced in the process of domestication. The fruits of these species play an important link in the food chain and ensure the diversity of food. The importance of these species is emphasized particularly over the last twenty years, with the increasing interest in organic (biological, ecological) production of fruit. In comparison to the varieties of fruit trees, wild fruit species have several advantages. The main advantage is that in the wildernes they grow without direct human influence, implying that they are preserved in an environment which is more or less disturbed by human activities. Moreover, the interest is drawn to those species which unlike varieties, preserved the ability of self-protection and biological balance. Today's modern fruit growing is developing in the direction of sustainable ecological and integrated farming, as the final product is to offer increased nutritional value and health safety.

Preservation of germplasm is essential for the successful creation of new and better genotypes resistant to disease, pests and environmental stresses, which will best meet the human's needs for fruit, now and in future. To prevent the erosion of genes, it is necessary to collect, store and analyze the genetic variability in wild relatives, species which have not been cultivated yet, and whose introduction into the culture would enrich the existing gene pool of fruit species. In this way we could preserve those species from genetic erosion and determine the origin of their gene centeres.

Medicinal and aromatic plants are an important part of the natural heritage of biological diversity in Republic of Srpska. People have collected and used them for centuries. These plants benefit to human health, local economy and cultural heritage, which is especially true for poor rural communities. They became popular and drew attention in the last decade as the attitutde towards them has changed, for these species have been marginalized and neglected by researchers in many ways. Uncontrolled collection of medicinal plants in our area, especially after the war, has resulted in disruption of genetic balance of populations and genotypes in certain species, even in those protected by legislation. This resulted in genetic erosion and the loss of many protected and endangered medicinal and aromatic species. Hence there is a need for urgent action to prevent the loss of individual endangered species and save the traditional knowledge that is still present in rural areas.

Main causes of threat to the survival and abundance of medicinal and aromatic plants in our area are: a) habitat destruction, b) excessive exploitation, v) changes in land use caused by agriculture and forestry, and d) the introduction of alien, invasive species (Program of plant conservation genetic resources of Republic of Srpska).

4.5. Forest ecosystems and species under *in situ* or *ex situ* protection

Till 2005 the mass selection method in Republic of Srpska picked the total of 56 seed objects, that is 35 seed stands, 4 groups of trees and 17 planted forests (Annex 5). It embraced 14 different species out of which 11 were conifers and 3 broadleaves: *A. alba, A. grandis, A. pseudoplatanus, C. lawsoniana, F. sylvatica L. decidua, P. sylvestris, P. spruce, P. nigra, P. silvestris, P. strobus, P. menziesii, Q. petraea and T. occidentalis.* The total area of all registered seed stands was 998,98 ha, while the reduced area was 709,40 ha. The management system, adapted to the purpose of these stands, can be taken as an example of good practice aimed to preserve and use the most valuable forest ecosystems, and thus to preserve their genetic resources.

During the preparation of the program (2011-2012) 32 new seed stands were registered (Register of the Ministry of Agriculture, Forestry and Water Management of the Republic of Srpska) and 27 other species were included. The registration process of these seed objects put the focus on a higher number of deciduous trees, and rare and exotic species that are of interest in the process of growing the planting material: *Prunus avium, P. cerasifera, piraster Pyrus, Malus sylvestris, Betula verrucosa, Robinia pseudoacacia, colurna Corylus, Juglans nigra, Castanea sativa, Acer pseudoplatanus, A. dasycarpum, carpinifolia Ostrya, Quercus robur, Q. ilex, Q. rubra, Fraxinus ornus, Celtis australis, Liquidambar styraciflua, Sophora japonica, Thuja plicata, Tsuga canadensis, Pinus halepensis, P. maritima, P. pine, Pinus wallichiana, Cedrus deodara* and *Cupressus sempervirens*. It should be noted that significant number of these objects was registered in the Mediterranean area (Center for management of Karst - 9 seed objects) providing prerequisites for successful reforestation in the area. Furthermore, all objects were registered in the category of individual trees and groups of trees, which means that the area of seed material (seed stands) remained unchanged.

In the Center of seedling production in Doboj there is a vegetative plantation of Scotch pine, which is now in a phase of seed production. Moreover, in 2009 the first progeny tests of Norway spruce were initiated (in they may serve as a seed orchard). These objects were of generative origins while the plants were at half-sib progeny which originated from the 60 highest quality spruce trees in six populations. Initial populations were evenly distributed throughout the territory of Bosnia and Herzegovina (in the range where spruce naturally grows), and progeny tests were established at 4 sites in 4 different ecological vegetation areas.

Botanical gardens are scientifically and technically suitable for *ex situ* protection of endangered species. In its campus, the University of Banja Luka founded a botanical garden which covers the area of 5,3 ha. An arboretum, grown in the Botanical Garden, comprises of 266 trees covering 39 species which represent the flora of the area.

5. FACTORS THREATENING GENETIC DIVERSITY IN THE REPUBLIC OF SRPSKA

Ever since man had begun to use natural resources, he has continuously interfered in forest ecosystems. Human-induced extinction of organic species during the last 200 years, which was rapidly intensified in the 20th century, left the Earth with significant reduction of genetic diversity and depletion of the gene pool. The constant pressure on the forest land and the effects of unsustainable utilization of forest resources, put the potential of forest genetic resources in danger to the extent that it may be lost forever, before man can discover it, not to mention use it. Furthermore, the loss of forests and degradation process cause major global concerns, despite enormous efforts to ensure sustainable forest management. There is also an increasing awareness of the critical values of forest genetic diversity, which should be used as a tool when addressing global issues such as the climate change.

Among the main causes of forest loss in the world refers to the misunderstood values of forest resources and trees, and the generally accepted standpoint that they are not economically important, as well as the policy framework which enables the conversion of forest land which is then used for different purposes (e.g. agriculture, pastures, mining, infrastructure development and urbanization). This problem is often due to the maximization of short-term economic profit and lack of forestry policy, which is based on a good understanding of the forests capacities as a source of profit and products for local and regional markets, and services which forests provide to other economy sectors.

Changes which reduce biodiversity, and consequently the genetic diversity in the world, in a greater or lesser extent, are expressed in the Republic of Srpska. Factors contributing to the loss of genetic diversity are (Ballian D. Kajba, D. 2011):

1. The destruction of natural habitats and their replacement with secondary or artificial habitats adverse for the survival of native species;
2. Introduction of non-native species causing changes in indigenous flora and ecosystems;
3. Excessive exploitation;
4. Direct or indirect pollution of water, air and soil, leading to a gradual, and sometimes abrupt changes in the structure of biodiversity and the genetic diversity.

Strong synergy among these factors makes it difficult to separate their individual effects. It is possible to single out factors that directly destroy habitats, such as total (pure) deforestation, flooding canyons and artificial reservoirs, unplanned expansion of urban areas, etc. In most cases, natural habitats are being destroyed gradually and indirectly, through interventions in natural ecosystems which are often thought to be "small" and "insignificant", by partial exploitation of populations of certain species or ecosystem components ending with all sorts of pollution which have cumulative effects. Not all species in forest ecosystems are evenly endangered. Natural genetic mechanisms are not sufficient to confront the loss of genetic diversity and to maintain the species flexibility.

Negative effects are increasingly intensified and accelerated even within the protected nature areas (reserves, strict nature reserves and national parks) in spite of efforts to have biodiversity and genetic diversity as one of the strategic directions our in Republic Srpska policy.

5.1. Deforestation and fragmentation

Agricultural land and the construction of infrastructure (urban development, road construction, industrial and power plants) in Republic of Srpska, have found their way to at the cost of the destruction of forests and forest lands, which led to the fragmentation of populations hindering and even preventing the exchange of genes, which is the main prerequisite to maintain the genetic diversity.

Negative impacts, not only on the genetic diversity, but on biodiversity in general, can be causes by the following activities in forestry: different types of logging (clean, sanitary, thinning), over-exploitation of timber and reforestation. The pressure of the timber industry in the scope of deforestation (**adapting the oversized capacity of wood processing**) is one of the major problem in the management of forest genetic resources in the RS.

In our country the Law on Forests prohibits clean loggings, because they lead to habitat destruction of primary forest species which are then replaced by secondary ecosystems of lower biodiversity and less productive capacities, causing the fragmentation of forests. Harvesting activities on a larger area are possible only in cases of fires, wind- or snow-breaks.

Thinning and salvage logging produce negative effects even though they are not immediately visible, they are soon manifested through trophic disturbance (pertaining to food and nutrition) and cenoses aspects which give the base for the ecosystem stability. (33 srp)

One particular problem in forest genetic resource conservation presents the logging of those trees which are estimated to be several hundred years old under the excuse that they are too old and sick. Loggng of these old trees causes the loss of unique or rare genotypes of species and shrubs. Seed material of these trees contains genetic codes which give the key of the adaptive proficiency and capacity to survive in diverse and changing abiotic and biogenic conditions of their habitats. The removal of these trees has negative effects since it can cause the material loss which is critical for gene banks of forest species and disturb the balance of the ecosystem. For this reason, many stands of these exploited forests become hypersensitive to various influences, and some of them gradually dry, etc...

Constant and selective directional logging of high-quality forest trees reduces the size of populations. Moreover, these activities can reduce the size of a population to the extent that its cultivation becomes impossible, and if the accidental pollination is hindered the population can become extinct.

5.2. Damage in forests due to the air pollution

Transport and industry are the main air pollutants. Basically almost all forms of air pollution are due to the human need for energy which is obtained at the expense of burning wood, oil, coal or natural gases. Air pollution has cumulative effect which affects the biodiversity of natural ecosystems, primarily through a gradual change in the structure of the biocenosis.

Air pollution can have direct or indirect impact on plants. Direct effects of the increased concentrations of harmful substances in the air cause the loss of chlorophyll and color change in plants, tissues and organs gradually die, processes of photosynthesis and growth stop, and eventually the dry and die. Pollutants which are released into the air, deposit and dissolved in water enter the soil, and then the plant. In this way they get into the process of circulation of matter in nature.

The effects on the genetic structure of populations have derived from the results considering different probabilities of individual or population survival, or the influence on reproduction process by reducing the abundance of flowering capacity or hindering the process of fertilization.

5.3. Climate change

In the upcoming decades, forestry will face big problems, firstly the climate change and its effects on forests. In the last fifty years, some human actions led to rapid climate change. The increase of the CO_2 concentration contributed to the greenhouse effect, increased the UV radiation, ozone, global warming, etc. The mean annual temperature in Republic of Srpska is expected to increase by 0.3 to 0.5 ° C per decade, i.e. 4-4.5 °C by the end of 21 century (UNDP, 2009). This will result in the reduction of forest vitality and its gradual decline. Forests of the Republic of Srpska are in the same (or very similar) situation as other regions in the world are. It should be added here that the most vulnerable communities are those of higher diversity capacities.

Loss of genetic diversity can be expected due to:

1. Moving the boundaries of some forest ecosystems in relation to latitude and altitude;

2. Different natural surface redistribution of forest types in relation to one another;

3. Retreat of certain communities due to the fierce competition between communities might lead to their disappearance

4. Different structure of some plant communities accompanied with disappearance of old and appearance of new species in relation to stratification and social status;

5. Some tree species change the attitude towards the light;

6. Forest communities will be more exposed to various negative influences that are directly or indirectly caused by the climate change. The above effects will directly affect the capacity to preserve biological diversity and rational management of this resource. Additionally, the expected effects directly affect the ability and the intensity of drawing up plans for sustainable forest management.

7. Critical moments arise due to the lack of harmony among the influences of climate parameters and the occurrence of phenophases, specific for each region. Climate change is reflected in the increase of mean annual temperatures in different periods and in the reduction of precipitation amount during summer. The coincidence of periods of drought and high temperatures, accompanied with negative effects of pollutants decrease the vitality of trees and creates optimal conditions for the growth of many pathogenic organisms.

Reduced capacities for biological adaptation as well as limited diversity are expected. The most vulnerable are communities and species which adapt ability is limited, here it is the case with the mountain and coastal communities, reservations, or endemic species, species that inhabit specific habitats and species of a slow and hindered reproduction.

The key problem is the adaptation of forest ecosystems to climate changes that are rapidly taking place. The appropriate measures in forest management may to some extent reduce the environmental and socio-economic consequences of possible deterioration of forests affected by climate change. Therefore, forestry should address the potential consequences of climate change.

It is well known that forests are critical absorbers of carbon dioxide, the primary greenhouse gas, on the other hand the deforestation process makes forests its source. The loss of forest participates in greenhouse gas emission with 12-15%, which is about the same as it is emitted by the world's transportation sector. It is practically impossible to avoid the adverse consequences of climate change if we do not take this issue into the consideration. For this reason, forests are part of the solution in the fight against the climate change.

5.4. Water regime

The construction of artificial reservoirs in canyons and ravines annihilates populations and ecosystems within the flood zones. One example is the loss and final fragmentation of the stand of Serbian spruce (*Picea omorica/Panc./Purkyne*), the endemic-relict species of this area in the canyon of the Drina River.

Interventions in water balance can cause changes in ecosystems by increasing or decreasing the groundwater level. The permanent lowering of the groundwater level is hard to bear by those tree species which are supplied with the water in dry periods during their growing season. This reduction does not only affect physiological processes in a tree, which depend on the presence and circulation of water, but also creates beneficial trophic conditions for the development of different defoliators and other tree pests and pathogens. The permanent increase of the groundwater level makes swamps, reduces aeration and causes oxygen deficit in the soil, as well as root rot. These changes can lead to the death of trees or they can alter the competitive relationships between species.

5.5. Biotic and abiotic damage

The loss of genetic diversity can occur due to the increased insect attacks, plant diseases and destructive abiotic events (storm, excessive snow and wind damages). These incidents have already occurred in this area, especially insect attacks and plant diseases in fir and spruce forests.

The above-mentioned climate change will mainly induce: the moisture reduction in the soil, the occurrence of climate extremes, the shortening of the growing season will hamper the reproduction and reduce the resistance to harmful biotic factors causing the emergence of pathogenic fungus, infestation of insect pests, causing forests to dry to large extent.

Fires can also be classified among the greatest threats to forest genetic resources. Every year there are about 100 forest fires in this area which burn thousands of hectares of forest. In 2008 there were 158 fires which burned 4,903 hectares of state forest, causing the estimated damage (in terms of wood products) of over half a million (information on the state of forestry in Republic of Srpska, 2011).

Grazing and fire can disrupt the natural regeneration, introduce new selective forces and effects on competition among species. Severe fires can cause the total destruction of the ecosystem, and thus initiate migration, which will include a new species. Many forestry ecosystems are adapted to periodic fires, but frequent fires could cause problems in the regeneration of certain species. Such processes can be best controlled by observing the development and distribution of species and size classes of trees, including the regeneration capacity. Regular monitoring is of a great importance, because it can react if conservation goals are compromised.

5.6. The effects of historical forest use

Throughout the history forests have represented one of the main natural resources in Republic of Srpska. Even though there were activities of using large amounts of wood material for ship building in Herzegovina, the economic value of our forests has started to gain interest since the early 19th century. Then the massive exploitation of beech and oak forests began. The arrival of the Austro-Hungarian Empire brought great changes in the ownership structure, as well as in the methods and organization of the production process. Among other things, it regulated cadastres, introduced several categories of forest ownership and forest land, initiated industrial timber processing, and eventually formed the Forest Service. The Ministry of Forestry and Mining was established in 1919 and was in operation until 1965. The harvesting activities were so intensive that they left thousands of hectares of barren land behind. After World War II the major changes in the forest sector occurred in Republic of Srpska. Mechanization was introduced at all stages In the production of timber products (Proposed Strategy of Forestry Development, 2011).

The development of wood processing technology, mechanized harvesting activities, skidding and extracting activities within the last 50 years have provided intensive and easier harvest per unit of time. At the same time, the unevenly distributed road networks have caused differences of the logging intensity within the whole area. And today, due to the oversized capacity, timber industry often bears down on forests by requesting the harvest of higher volume than they have at their disposal, i.e. wood processing service has unjustifiably been assigned to forestry.

Specific requests that communities had had for many years led to the selective use of certain types of trees and the removal of other species. In the second half of the 19th century there were massive afforestation activities which contaminated the gene pool of neighbouring populations through forcing coniferous tree species by utilizing the reproductive material of unknown origin, i.e. little attention was paid to the origin of the plant material, inadequate provenances were used etc.

5.7. Using unsuitable reproductive material

Incompetent afforestation (for forestry and wood industry purposes) which forced monocultures of conifers and non-native species and genotypes, as well as the improper species selection used to be common practices in the region. These activities neglected many of our indigenous, endemic and relict species of trees, and lead to a significant reduction of biological and genetic diversity of forest ecosystems. On the territory of Republic of Srpska nobody has defined any provenance region (or seed zones) yet.

The most common mistakes and the consequences of using unsuitable reproductive material are:

-Collecting seedlings from populations that have limited genetic diversity (contain a small number of genes, do not reflect the variability of the species or population) and are unable to adequately adapt to other site conditions or show poor results

-Inadequate identification of natural material objects

-Lack of information on forest reproductive material

-Lack of reproductive material of natural species whereby preference is given to the introduced species

-The use of a small number of plants per unit area during the artificial establishment of forests, so that at a later stage we do not have sufficient number of plants that would form the genetic structure of populations,

-The establishment of new forests from seeds collected from a small number of mother trees, narrowing the genetic variability,

-Introduction of foreign plant material among native species, leading to a "contamination" of local populations (which were introduced by genes)

-Lack of planting material due to the poor results of planting the seedlings in the field or the reduced number of seedlings due to damage caused by abiotic and biotic factors.

5.8. “Genetic pollution” of our forests

Unlike many “visible” contamination agents (dumps, landfills, leaking chemicals) “genetic pollution” hasn’t attracted much attention yet, because at first glance it seems "invisible". However, our modern scientific achievements in the field of genetics (especially the use of molecular markers) pointed out to this great danger, and have initiated a lot of campaigns against genetically modified organisms, which are just one form of “genetic pollution” (Ballian and Kajba 2011). A significant problem in terms of genetic pollution is the above mentioned uncontrolled transfer of forest reproductive material in order to "help" new plants (often invasive) to acclimatize quickly and take roots in their new environment, and thus suppress native species which have adapted through natural selection to the area. The bigger problem arises with the appearance of uncontrolled crossbreeding of indigenous and alien species and the appearance of their "hybrids" in nature. The problem becomes more significant as the transfer of seeds is done at greater distances (import and purchase seeds from abroad).

5.9. The effects of inadequate practice

Forest genetic diversity may be reduced due to inadequate practices such as:

1. Lack of institutional framework for the management of biological and geological diversity;

2. Poor (not enough) research activities of biological (genetic) and geological diversity;

3. Inadequate and dysfunctional legal basis, the insufficient implementation of existing laws;

4. Lack of awareness in government and non-governmental organizations on the importance of biological and geological diversity for the sake of community stability and poverty reduction;

5. Systems of forest management do not respect the principles of conservation of forest genetic resources;

   5.1. Selective logging (tree marking) of the best phenotypic trees before they enter the reproductive process, i.e. reach physiological maturity;

   5.2. Negative selection done by leaving "minus" versions of trees in the forest which presence and gene exchange negatively affect the quality of the offspring;

   5.3. Harvesting of species that are in a high demand (for example, fruit-trees logging) can destabilize the structure of the ecosystem and lead to the extinction of species, etc.;

6. The lack of determination to employ international instruments governing the sustainable management of biodiversity;

7. Lack of standards and strategies for sustainable use of natural resources;

8. Increased illegal trade of endangered species of plants (fruit trees), animals (rare and capital items), and mushrooms;

9. Insufficient involvement in international projects and

10. Insufficient dialogue / partnership.

5.10. Strictly protected nature reserves / conservation process

Past practice of separating nature reserves on the principle of strict protection (conservation) has not given satisfactory results. More attention should be paid to the active management of the existing protected areas within smaller areas of valuable rare species, since the natural succession may occur. Tree species of “meta-structures”, in which local subpopulations periodically become endangered by the recolonization process from neighboring subpopulations, are at high risk of being permanently lost in small reserves.

In those forests which are excluded from the system of management, the survival of endangered, rare tree species may be threatened by the succession process of biologically more resistant and competitive individuals. Part of the answer to the question of the conservation of forest genetic resources lies in the management of protection forests and special purpose forests. These studies and the obtained results can be initial point to request an area for conservation of rare and endangered forest species via selective interventions and influence on the succession process which may threaten the survival of some species.

Upon the introduction of FSC standards In the territory of Republic of Srpska, rare and important species in economic management are being registered and recorded. This may be the first step in preserving and adapting farmers’ practice according to the conservation needs of rare and endangered species, paying special attention not to undermine the economic aspect of the trade. In this way we can justify certain and specific interventions in protection forests and special purpose forests.

6. IN SITU MEASURES (PRESERVATION OF GENETIC RESOURCES IN THEIR NATURAL ENVIRONMENT)

There are different conservation strategies in practice. *In situ* (on the spot) implies the conservation process of continuous maintenance of populations in the environment where it originally developed under the assumption that they adapted to the habitat (Frankel, 1976). This type of care is generally applied to the naturally regenerated wild populations in protected or managed forests, and also to artificial regeneration in planting or seeding processes, without direct selection in the same area where seed was collected. This form of genetic resources conservation is probably the most important strategy, and sometimes the only viable approach. This is particularly evident in developing countries which deal with small amount of allocated resources for the conservation and insufficient basic information on species distribution and information in general. *In situ* conservation is usually preferred as a strategy to preserve the majority of the wild species, including some of the wild crop relatives since they enable populations to continue to be exposed to evolutionary processes.

The advantage of *in situ* conservation is its function to preserve ecosystems, not just species or genes. This means that programs of *in situ* conservation of selected species often result in successful preservation of a large number of related animal and plant species. Most species cannot be conserved in *ex situ* gene banks or plantations for biological and technical limitations and limited resources. Thus, the preservation of the majority of plant genetic resources in the world will rely on *in situ* conservation.

It should be noted that *in situ* conservation of forest genetic resources relies on gene reserves, i.e. genetic conservation of forests (*Gene reserves* or *Gene Conservation Forests*). In both cases, they are not directly related to the system of strict nature protection. It is also worth mentioning that **the genetic conservation of forest does not much differ from regular forest management.** There are only 3 key requirements:

1. According to the Pan-European minimal requirements for acknowledging the area of genetic conservation of trees, each registered unit should be officially acknowledged by the state agency. Some sort of a simple project or design may be done on the unit which is taken into the consideration.

2. The minimal size is 100 hectares. Smaller area size is allowed in the case of rare, endangered and extremely valuable local population.

3. Natural regeneration. If natural regeneration fails for any reason, the reproductive material from the same unit is to be used for genetic conservation purposes. Those seedlings obtained via natural regeneration in other parts of the same unit can be used for this purpose. Buffer: In order to prevent genetic contamination, only reproductive material from the local provenance regions can be used in the bordering areas of the genetic conservation area.

6.1. *In situ* conservation of genetic resources in managed forests

In situ conservation of forest genetic resources comprises the following logical sequence of events:

- Set priorities by identifying genetic resources of priority, often at the level of species. This should be based on current or potential socio-economic value of the species, and their conservation status within the ecosystem.
- Determine the genetic structure of priority species.
- Assess the current level of protection of certain species and their populations.
- Identify specific conservation priorities, namely: the individual species at the population level, a group of species at the ecosystem level, including the identification of geographic distribution and the number of populations embraced by the conservation program.
- The choice of conservation strategy and identification of conservation measures - biological and economic options.
- Organization and planning activities considering specific aspects of the conservation process.
- Terms and development of guidelines for the management system.

Practical experience shows that the management of genetic resources involves two strategies which partially overlap, firstly, the management of natural forests, which pays attention to their genetic resources, and secondly, the establishment of networks of smaller areas for gene conservation. This does not imply that we have to include all species in the genetic resources conservation process throughout the natural production forests and protection forests. The major challenge is to find the balance and synergy between these two approaches. This will depend on biological factors (species structure, distribution and ecology), as well as the current and future utilization of forests. Areas for specific genetic resources can be established in both types of areas. Additionally, general management principles of naturally produced forests and protected areas should take into the account the protection of genetic resources.

Strategy 1. Sustainable management of natural forests which leads to *in situ* gene conservation. The majority of forest genetic resources can be preserved via land management of natural forests, especially in certain areas of genetic conservation. For this reason it is crucial to keep forest owners and those who manage forests well informed about how they can conserve, manage and benefit from forest genetic resources in natural forests which are under their management.

Strategy 2. Protected areas as a vital component of the program for the conservation of forest genetic resources. Networks of protected areas are established in most countries. However, protected areas do not provide automatic conservation of forest genetic resources. First, there may be insufficient number of important population. Second, viable populations may not be present, and the usual changes may, without adequate management measures, affect the species selected for conservation actions. Protected areas often form a "backbone" which can later be used as a base to establish more specific networks for certain stands intended for the conservation of priority species, including non commercial ones.

6.2. Defining priorities for the forest genetic resources conservation

Although the goal of forest genetic resources conservation can be easily explained, its implementation can be very complex and expensive. When there are thousands of species distributed among several local populations (crossbreeding among groups of individuals), of which each has thousands of variable genetic loci, the first priority should be placed at the species level; only then priorities can be assigned among populations. The effective program of species conservation needs to take into account the range of geographical distribution of species and metastructure types. Without this information, it cannot be said for sure that the genetic diversity of target species has been saved eventually. For this reason, the majority of national programs for forest genetic resources conservation have to deal with conservation of locally adapted populations.

Bearing in mind the goal of genetic resources conservation, tree species can be classified into three main groups:

α) species which cannot be conserved by any possible conservation measure

β) species which will survive even without management

γ) species which will survive if they are suitably managed (as far as resources allow).

As Koshy et al. (2002) mentioned, by selecting target species and regions for the purposes of more detailed genetic studies, we would obtain information necessary to identify priority species. These authors also point out two levels of selection of the target groups, one for research and risk assessment, and the other one for the management of certain risks.

Divergent opinions can be expected when defining priorities among woody species. Official agencies in forestry will likely attach greater importance to matters of their interest and express their priorities, unlike it will be the case for people who live in the forest or benefit from it, which on the other hand may differ from the standpoints of farmers and others who exploit the forest. It is obvious that in order to be successful *in situ* conservation program needs to target species of immediate interest, or species which pose a problem for the party which manages the land and / or to a landowner: which will have great impact when planning *in situ* conservation programs. Also, it is critical to take into account the species and provenances of great economic importance, especially in other areas, but which are currently of little importance in their natural habitat.

Bearing in mind the fact that available financial resources will be limited for the programs dealing with special protection of forest genetic resources, it is necessary to consider which of priority species are in the greatest need for the conservation process. These activities may be suitable for various species if one resource volume is compared (the level of genetic diversity and variability within species) with vulnerability and threats to populations and / or ecosystems they are part of.

The main criterion to include species in the genetic resources conservation program is their current and potential future value. Genetic priorities are to be identified in the line with costs and benefits associated with the resource in mind. For this reason the value of the selected species or populations is to be qualified, and the risks associated with various management options to be assessed. Very often, such quantification is not possible, especially when you take into account the potential value.

When considering the large number of species and their distribution in the gene conservation planning process, it is essential to pay attention to the following items: (1) the best way to identify species which should be included, and (2) how to select the population in the process of conservation.

6.3. Assessing genetic variation: determining the genetic structure of species

Once the decisions at the level of species are taken in the process of gene resource conservation, it is very important to pay attention to the process of conservation at the population level. In practice, the term "gene conservation" implies that the genes are the resources we want to keep, because we consider all genes to be potentially useful. We try to carry out the conservation of genetic variation and the processes which will maintain the genetic variation, consequently we can succeed only if we maintain the selected population.

Reliable information on the distribution of genetic variation, within and outside the geographical regions, are very important in terms of establishing an effective network in the conservation process. Genetic variation can be accessed via different techniques. Morphological and metric characteristics can be observed in the field experiments, or by biochemical and molecular markers in the laboratory. However, field work and laboratory studies are expensive and time-consuming. If the person who is in charge of the conservation lacks genetic information, then he/she can only assume that genetic variations will perform some or almost entire forms of the ecogeographic variations. This approach may not always be correct, but it is one of the safest assumptions in the conservation process.

As long as we lack information on the genetic structure of populations, we must rely on the assessment of the ecogeographic variation within the distribution area that is of interest. Genealogical zone can be defined as an area where we cans assume the phenotypic or genetic characteristics of the species since the environmental conditions within it are sufficiently homogeneous.

6.4. Assessing the conservation status

Conservation status refers to the current situation of genetic resources and immediate risks they are exposed to. Questions that can be addressed here are:

- Are potentially significant population at high risk?
- How well are the rest populations protected?
- Do the remaining protected populations adequately cover geographical, ecological and genetic variants wherever they appear?
- What are the future trends or risks (harvest, climate change, etc.)?

These issues need to be addressed using the best available information:

- The previous and current geographic distribution.
- Prevailing samples which are directly used, such as logging, planting and breeding species (including the introduction of species / provenances that are mutually crossed) or indirectly via the alternation of patterns considering the land use samples.
- The incidence rate within the protected areas.

6.5. Determine specific priorities: identification of populations that comprise the process of conservation

By comparing genecology zone with distribution of species that are of interest, it is possible to identify the number of areas that should be protected or sampled for conservation purposes. It would be desirable to preserve all major variations within the genpool, paying attention to keep the number of stands, which are involved in this process, at a feasible level. In practice, the comparison of genealogical distribution and conservation status comprises of several steps:

• Overlapping genecology zones with: natural (previous) and current geographical species distribution, the occurrence of the species in planting programs and within protected areas, locations of provenances which have already been defined as important.

• Consider other factors which may affect the structure or the maintenance of genetic variation, conservation status and investment conditions in the preservation process, for example, variations of forest types via distribution, the capacity to reproduce and spread seeds, size and geographic location of previous and ongoing planting programs, and the origin of the materials used in the process of planting, the conditions for safety and the management of various *in situ* and *ex situ* investments, land rent and related issues such as costs.

•Make decisions on the appropriate geographical or genealogical images, number of areas within zones, and the number of populations which should be preserved or sampled in each area: when species which are unevenly distributed are considered, it is necessary to consider the size, frequency and proximity of the identified groups of trees to achieve the adequate sampling level; in cases when programs comprise more selected species they provide the possibility to consider interspecies dependence within the ecosystem, as well as to rationalize the area in order to cut expenses.

6.6. *In situ* conservation strategies

When making a decision about the options in the conservation strategy, it is very important to define whether genetic processes will be retained or not. Genetic processes are usually related to gene frequency and genotype distribution alterations. Roughly speaking, when talking about the process of the evolution, conservation strategies can be divided into three categories (Guldager 1975):

• **Static conservation strategies**, where the genetic processes are usually not considered to be important. They aim is to keep the alteration of gene frequency or genotypic distribution as small as possible. It can be said that the aim of preserving the current set of genotypes possible by making a collection or a sample.

• S**trict evolutionary conservation strategy**, where the protection of genetic processes are of equal importance, as well as the preservation of current gene frequency within the population. It can be said that the goal of evolutionary conservation is to protect species, which can maintain good health in the long-term adaptation (such as development of old varieties), consequently, alterations of gene frequencies are expected to occur.

• **Evolutionary conservation** of populations which are exploited, has its goal in the conservation of populations which are genetically diverse and viable and grow in conditions that reflect conditions in managed or exploited forests or planted forests.

6.7. Organization and planning specific activities of the conservation process

When planning a program for genetic resources conservation, it is important to consider:

• Who provides the right of ownership and management at national and international level?

• What can happen in practice?

Administrative and research units within the public sector should make sure that all interests are taken into account. Upon the selection of populations and necessary measures, numerous activities will occur in the field:

• An overview of the field in order to verify the selection of the stand(s) for conservation.

• Separation, storage, care and supervision of *in situ* conservation stands.

• Collection, extraction, storage and multiplication of reproductive material for *ex situ* conservation.

6.8. The preparation of guidelines for the management of the conservation object

In order to maintain successful management and documentation, it is necessary to define precaution measures which are to be supervised by the use of specific technical guidelines. From the management point of view, it is useful to distinguish several *in situ* conservation levels and methods:

Conservation stands

Management and specific management interventions in each stand will depend on species traits and the land. The selected stand may be “pure”, in which case it is composed of only one species, and can be mixed, if composed of several species. In a case of a mixed, several species can be selected for the conservation purposes.

The number of individual species

• Mixed stand, where the goal is to conserve the genetic variation of one or more species, will be higher than it is the case with “pure” stands which contain only one species.

• Very conservative rule estimates that *in situ* stand, for species pollinated by the wind, should contain at least 150, and preferably more than 500 crossed individuals for each of the selected species.

• When it comes to conservation of quantitative genetic variation, approximately 150 individuals will show 99.7% of variations present in the initial population. It is considered that a few hundred individuals are sufficient to collect the genes of lower frequencies.

• For a population with a lower level of management, or when it is completely absent, we should take a larger number of individuals into account, since random events and demographic factors are affected by differences and natural variations lying in the basic biology of the species.

• The actual number of individuals selected for preservation within the population, should be determined upon the cost of maintaining a large number of individuals, for the purpose of collecting a larger number of genetic variations.

Regeneration and isolation

• The population within the *in situ* conservation should be regenerated with the use of the genetic material originating from the same or a nearby stand, maintaining the minimal level of external genetic influences as possible (in the form of pollen contamination from outside sources).

• In practice, these calls for some types of isolation, which will mostly depend on the reproductive biology of the species. However, isolation belts of 300-500 meters are considered as adequate for most wind pollinated species.

Maintenance

• The need for nurturing depends on the species and habitat conditions. When necessary, these measures should favor the regeneration and stability processes of trees and stands.

• Special management systems, which may include logging activities of competitors (invasive species) and manage grazing or fires, might be necessary to be introduced for some populations.

• Thinning is considered as the best measure, especially if it stimulates regeneration. In pure stands, systematic thinning is recommended in order to maintain the current genetic composition of the stand.

Exploitation

• In some cases, conservation can be combined with various forms of forest exploitation, provided such activities do not alter the genetic composition of the stand.

Field conditions

• Field conditions and the quality level of sites are of great importance for both *in situ* and *ex situ* conservation. The choice of location and management has much more effect for the *ex situ* conservation, however, the quality of the site and many other factors are to be considered during the selection of *in situ* stands. The long-term conservation status should also be taken into the consideration.

6.9. Selection and management of *in situ* conservation areas

Selection and the management of *in situ* conservation areas open following issues:

• How many conservation areas should there be?

• How big should the area be?

• How to select individual populations and habitats?

• How to prepare a management plan for these areas?

6.9.1. The number of conservation units

The process of habitat and population selection which will be included in gene conservation of certain species should be based on known or expected distribution of genetic variation. Unfortunately, the low number of genetic research work, even if accompanied with available information, faces difficulties in interpreting information to identify habitats for conservation. However, special attention should be given to priority species, even though their genetic position is not well-known. The same applies to any geographical variation or the ecotype (including subspecies), which may be taxonomically identified.

In the absence of data on the distribution of genetic variation, the least one can do is to engage diverse locations of biogeographical species distribution via establishing conservation stands in a way they are more or less within their natural range, together with extreme or rare populations (Leding 1986). More precisely, regardless of the fact whether there is genetic information about the structure of the population, the genecology approach (Graudal et al 1995, 1997) identifies different genecology zones. It is assumed that genetic variations follow some schemes of environmental variation. Even if this is not true, such an approach can provide an effective “random” population sample throughout the range of species distribution. Thus, populations should be sampled in order to cover all genecology zones

Genecology zoning criteria are based on:

• any information obtained by genetic research which may be available for selected species, or other similar ones,

• local distribution of forest ecosystems,

• information from weather report station and the climate area,

• physiographic maps,

• geological surveys or soil research.

The above set of information makes a very important input, and in the process of zoning it is necessary to collect and analyze this kind of information. In practice, it is recommended to conserve more than one population per genecology zone. In the field, the number of selected populations for conservation depends on the risk or threat at the population level, available resources for their management and maintenance, as well as the expected variations, e.g. economic value and genetic specificity.

In most cases, a relatively small number of gene populations which have been selected for conservation, will be sufficient for each species, although it is undoubtedly true that larger number of areas will provide more reliable data.

6.9.2. The size of each area designated for conservation

Since the genetic diversity can continuously be disrupted within small populations, stands which are designed for conservation should be of minimal size to preserve these genotypes. Although the low-frequent genes will rapidly lose a large part of the genetic variation within small populations, the high number of genetic variations can be maintained within a relatively small number of individuals, at least for several generations. Some conservation programs give priority to low-frequency genes, calling for larger populations. Practice has shown that for this reason, the size of the stand designed for the conservation is highly variable, although, whenever possible, it is best to avoid smaller populations.

The size of the stands for the process of conservation will depend on the density of reproductive trees of selected species. Of course, there are many other nongenetic factors, including the possibility of natural disasters, various management aspects, maintenance of species which are in indirect contact with key species (especially mammals or birds that pollinate or scatter seed), which may condition larger populations.

6.9.3. Selection of the individual population within each genecology zone

Ideally, the best location of the area for the gene conservation is on the land under long-term rent contract, and which is managed by authorized agencies with qualified staff, resources and committed to the management and land protection. Forests and trees in private ownership are usually considered less safe and suitable for the process of conservation, although this is not always the case. The main factors for the inclusion of certain areas or stand in the *in situ* gene conservation system are:

- the number of selected species and the presence of key related species,
- low risk / threats (including the safety of land tenure)
- commitment and adequate "Agency" in charge of resource management,
- support to local residents, owners and users of the area,
- compact shape and the presence of forest buffer zones and
- the possibility to conserve other priority species.

If the species are already present in protected area, it is necessary to identify those species and then to assess the most appropriate maintenance level, in terms of short and long term period. As far as the *in situ* conservation of populations outside protected areas are concerned, the adequate representation of the population is to be achieved. Therefore, it is important to identify and select populations which will fill that gap. In addition, the selection of habitats outside protected areas can be particularly effective in the process of genetic resources conservation of certain species, which are suitable for active management measures. However, in the case of protected areas, they are either banned or are likely not to be undertaken.

6.9.4. Development of a management plan for each conservation unit

The habitat intended for the *in situ* genetic resources conservation of priority species will be part of a conservation stand network. Management plans will be designed for each habitat, which will then be a part of a general management plan for genetic resources conservation. In addition, each habitat will be part of a larger area under forests, or the area which is managed in terms of natural production forests, or part of a larger area of protected areas such as national parks. Habitat management plan will also be one of the elements of the forest resource base for the area where the habitat is found.

Such management plans at the level of habitat can best be developed in a consultative process which involves all stakeholders, especially the owners, managers and users, then the neighbors, and forest geneticists who can contribute to the overall process of planning and implementing programs of gene conservation for certain species.

The project should be simple and easy to be understood. It should include:

• General information on the area designated for conservation, including maps, the area range and boundaries, the status of property owners, its history, forest inventory (species structure, size class, etc.) and environmental characteristics (climate and soil).

• Key documents of the area and of the selected species, including biological inventories, special lists, ecological and genetic studies of selected species that are involved in the process of conservation.

• A description of duties, responsibilities and rights of those involved in the management and exploitation of protected areas and their resources, including the permitted and prohibited activities and exploitation.

• The program, timetable and budget for monitoring, and managing trees, which are involved in the process of conservation.

• Assessment of potential risks and threats to the species and a backup plan, including possible complementary measures of the *ex situ* conservation.

In Slovakia, for example, a project for the conservation of forest genetic resources comprise:

- Short description (one, max two pages) of the conservation unit, including the description of the habitat, forest type, forest species - structure, age structure, regeneration, property rights, historic, existing and prospective forest management.

- Definition of the long-term goal (50-100 years) and medium-term objectives.

- Guidelines for the renewal (regeneration) process, for example the length of the regeneration period, type of felling activities and their intensity. Alternative measures have to be in line with activities which might arise in future, even with natural disasters which might cause large scale destruction and loss of some age classes of priority species.

- Short-term (ten-year plan) guidelines for forest management, because most of the areas where genes conservation is performed are managed and exploited.

- Maps: 3 maps are required:

• Phytocoenological map,

• Forest Map - showing boundaries of the forest area, age structure, terrain and infrastructure of the forest.

• Harvest Map– critical one since it describes the initial state, and provides an overview of silvicultural measures and the schedule when they are applied (thinning, harvest updates, etc.).

For each 10-year period of planning and management, the current forest map and harvest map are added to the project of forest genetic reserves.

6.10. Conservation of forest genetic resources in protected areas

Protected areas are defined as: "areas, dedicated especially to the protection and maintenance of biological diversity and associated species resources, and managed via legal or other effective means" (IUCN 2003). They cover various aspects, ranging from the managed areas, protected watershed, national parks and strictly protected reserves, to the "sacred" forests. Currently protected areas do not have appropriate locations for the forest genetic resources conservation, since they do not contain all species or genetic variations. Management regimes of protected areas are usually designed for the purposes of forest ecosystems conservation, which are often compatible with *in situ* conservation of genetic resources - but not always. Further efforts are necessary in the conservation of selected species, such as those mentioned in the previous chapters. In order to enhance biodiversity conservation, Blockhus et al. (1992) suggest that systems of protected areas are established in order to cover:

• representative areas of all types of forests,
• examples of forests that have high diversity of species and / or high levels of endemism,
• forest habitats of rare and endangered species or associations.

Article 8. of the Convention on Biological Diversity (CBD) from 1993, which deals with *in situ* conservation, requests each contracting party to establish a system of protected areas or regions where special measures are taken to conserve biological diversity. It is desirable for the new protected areas to be located in areas that will enhance their contribution to forest genetic resources conservation.

Although the primary goal of most types of protected areas is the conservation of genetic resources, inadequacy of the existing protected areas for the genetic resources conservation (IUCN 1993) is observed. Establishment of *in situ* gene conservation areas, as well as specific categories of protected areas can be based on the following factors:

• the main goal is conservation of the intraspecies genetic variation,
• protection of genetic resources of economically important species and
• regulations on the use of genetic resources by researchers, breeders and for the purposes of *ex situ* conservation (Prescott-Allen and Prescott-Allen 1984).

Protected areas can also play a vital role in the preservation of forest genetic resources, supplementing the populations that are stored in managed, productive forests. In general, most of the protected areas have traditionally been subjected to quite minimal management activities, which are not related to protection aspects, either due to the lack of financial support or intentional of non-interfering approach in the management of strictly protected areas. Many protected areas are not close to be useful in long-term conservation, and for this reason it is necessary to put a lot of efforts and resources to manage selected species.

The general approach to protected areas, common for many countries, is based on the strategy shown in Table 5.

Table 5. Steps to improve the forest genetic resources conservation in existing protected areas

Step	**Activities**	**Target**

1	Collect and compare data about species found in the protected area	Documenting the species in the protected area and their status
1B If information is insufficient	Undertake detailed botanical inventory	Identification of the species of trees and their number.
2	Identify priority forest (especially woody species) genetic resources	Identification of species / populations of priority resources of forests and trees (as well as all rare and endangered tree species)
3	For each priority genetic resource / species determine whether there is a need for special protection and management measures	Identification of the priority forest genetic resources that need special management attention
4	Develop a general management plan and a plan for each species	Identification of necessary management and protection measures for the conservation of genetic resources and processes for priority species and synthesis into feasible management plan(s)
4B If information is insufficient	Conduct a research focusing on the selected species	Provide the information necessary to evaluate the management of specific conditions, unfamiliar species
5	Implement management plans	Build and maintain a healthy, viable population(s) of the selected species, via the effective plan(s) implementation
6	Monitoring activities and detailed review of priority species	Provide information to assist the interpretation and review of the successful management practices, as well as guidelines for future management decisions
7	Review of the management plan	Consider each component of the management plan(s), based on monitoring and other information, and if necessary, develop new approaches and practices

6.10.1. Strengthening the role of protected areas in the conservation of forest genetic resources

A number of specific measures that can be taken to strengthen the role of protected areas in the conservation of forest genetic resources are:

1. Consider the conservation of forest genetic resources in the process of planning new protected areas.

2. Improve communication and coordination among institutions engaged in the protection and management of genetic resources.

3. Carry out the inventory of forest tree species.

4. Institutional effectiveness in the protection of forest genetic resources.

5. Active management of forest genetic resources.

6. Restoration of degraded areas within the protected areas and buffer zones.

7. Establishment of additional protected areas in categories that implement management process.

8. Ensure that forest genetic resources, which are located within protected areas, continue to be available for research work, conservation and other purposes.

9. Identification of national and international priorities.

10. Ensure the sustainability of protected areas.

We should be very careful when defining the preserving activities of forest genetic resources in strictly protected areas. The regime of non-intervention in protected areas poses a problem for long-term environmental stability and reproduction of genetic resources. In the best case, the following threats are to be considered:

- Unnatural selection factors, which effects are not explicit in the short term period, are present in most parts of strictly protected forest communities. Such factors are, for example, long-term air pollution, climatic extremes repetition, altered dynamics of pests and diseases, the spread of invasive species, wildlife overpopulation, etc.

-During the bark beetle outbreak in the neighboring secondary coniferous forests, and when measurements are permitted in strictly protected areas, mature trees can be lost over a short time in mostly natural conifer forests (eg. coniferous forests in the Czech Republic and Slovakia).

- In too small populations, yew for example (*Taxus baccata)*, which are under the strict protection regime neither genetic enhancement via planting seedlings from other populations is allowed, nor the protection from competing species and wildlife. This increases the vulnerability of the protected population and the presence of the inbreeding.

Recommendation: The conservation of forest genetic resources needs to be dynamic and proactive. Its main objective is conservation and sustainable long-term goals. The success of genetic conservation largely depends on the active intervention in the name of regeneration of target species and involving (or at least-approval) forest landowners and forest managers into the process. **Protected area with the regime "without intervention" may be part, but not a central component of the forest genetic resources conservation.**

7. EX SITU CONSERVATION AND UTILIZATION OF FOREST GENETIC DIVERSITY

Ex situ conservation of forest trees genetic resources is mainly engaged in sampling and maintaining the largest possible genetic variation within and among populations of selected species. Forestry experts should intervene when it comes to the *ex situ* conservation, either via simple collection of seeds, storage and planting in the field or intensive plant breeding and improved access. Unlike crop breeders, forest tree breeders cannot quickly produce a new variety, nor can quickly create a breed for the existing variations among populations. Therefore, the existing genetic diversity in populations, is an important and fundamental to the conservation of forest genetic resources, particularly because it can affect the long-term maintenance of genetic diversity in viable populations. Particular attention should be paid to the preservation of genetic variation within species in the peripheral or isolated populations, in order to express high-level features, such as resistance to drought, tolerance to different soil conditions (Stern and Roche 1974), or features which will assist the protection from future climate change consequences (Muller-Starck and Schubert 2001).

The combination of *in situ* and *ex situ* conservation will be necessary for a detailed program of genes conservation. However, there are many situations in which *ex situ* conservation becomes the focal centre of gene conservation program. This is an extremely important component of many gene conservation plans and networks for most species, however, it may also play an important role for forest trees. Important features of the *ex situ* conservation programs of any species are:

• to be an important back-up measure, unless other measures of *in situ* conservation are impracticable or unavailable,

• to ensure that a range of diversity (phenotypic and genotypic) is available for species that are in the process of conservation and

• to manage the regeneration of native species outside its natural range (background), in the more controlled manner.

Available resources play a key role when it comes to determining the development strategy of any *ex situ* gene conservation program. Due to the lack of technology and resources to assess the number of available genetic variations within populations, *ex situ* collections are mainly based on the collections which represent populations from different areas or ecological zones, as well as on individuals within these populations as they may represent typical or specific phenotypic variation of morphological properties. Even though it is desirable to sample those populations for which we have knowledge on species genetics, many principles of genetic sampling are strong enough to capture the genetic diversity without such knowledge. In addition, different types of tissues or seeds that can be collected and then stored, archived, sow or planted, play an important role in the ability to maintain and preserve *ex situ* genetic diversity.

7.1. Issues to be considered in *ex situ* conservation

Decision on the choice of strategies and *ex situ* conservation methods for particular species will depend not only on their biological characteristics, patterns of genetic variation and the current status of conservation, but also on how much we know about the basic management and governance practice which are applied for those species. It is essential to determine which part of the plant will be sampled and preserved in the *ex situ* conservation process - the whole tree, seed, tissue culture, genetic material, or something else,. Another important aspect is the institutional capacity of the organization in charge, and the availability of medium and long-term financial means for successful *ex situ* conservation. In the process of *ex situ* conservation the following issues are to be addressed:

1. Define the hierarchical level of protection. The first point to take into account is the different level of genetic hierarchy: genes, genotypes, populations and ecosystems. In order to develop an effective strategy for *ex situ* conservation, key issues related to the goal of conservation, origin of the material that is conserving, the current status of the use and conservation need to be addressed.

2. Define the goals of conservation. When defining the objectives of *ex situ* collections and conservation programs, the first step is to determine the objectives of the sampling and recording activities of genetic diversity. In other words, we should ask ourselves whether our goal is the conservation of a representative sample of local species, or a representative sample of geographic provenance variation, a representative of genetic variation in a provenance or a habitat, or simply a genotype. The second step should be to determine the future use of this material. Will it be involved in the activities of breeding trees, in programs dealing with planting activities, or for the rehabilitation of species in their natural habitat? To make the *ex situ* conservation effective, it will require continuous investment, financial and capacity-building. Experience shows that such long-term commitments exist only if the objectives are defined and if there are some interests in the use of species or provenances in the future. If there aren't any interests, conservation process with low long-term value, the program which mainly depends on financial funds will be closed.

3. Are selected species used to establish new forests or not? The next factor to consider is whether the material is currently used for the establishment of forests or plantations.

4. Form of conservation: evolutionary or static? In the development of appropriate strategies for *ex situ* conservation we should determine whether to protect genetic processes or not. As previously described, genetic processes include all processes that causes alterations in gene frequency. A person who is engaged in conservation will have to decide whether the conservation strategy will aim to maintain the original gene frequencies of populations and thereby avoid the consequences of genetic processes-static conservation, or support the current adaptation and enable gene frequency alteration in accordance with local and relevant selective forces-evolutionary conservation.

5. Conservation status. Current status of species or provenances that are of interest, needs to be taken into account as this fact will affect the possibility and the approach to the sampling process. If provenances or species are in immediate danger of extinction, and there are only a few reproductive individuals left, then the most important criterion, immediate action, is independent of the conservation methodology. In this case, all the remaining material is to be sampled, and the method will depend on the status and biology of species - to quickly choose a conservation measure, in order to avoid further loss of genetic diversity.

6. The institutional capacity. Capacities of the engaged organizations is to be carefully considered when developing conservation strategies. The nature of activities that apply to *ex situ* conservation -

germplasm collection, storage, propagation, and handling seed plants, nurseries, planting, establishment of secure tests on the ground, banks clones - emphasizes the importance of long-term presence of organizations that are engaged in the process. *Ex situ* plantations depend on the continuous existence and effectiveness of not only their home institutions, but also of the relevant qualified personnel, who cannot be present during the entire period of *ex situ* conservation.

In future activities, the pilot phase of the program will establish and monitor different ways of *ex situ* conservation process, in order to clearly define advantages and disadvantages of each method (progeny tests, seed orchards, provenance tests, clone archives, seed storage, etc.). In this way it will be clear to what extent and which measures are considered the most relevant in terms of their effectiveness and further applications for these species.

7.2. Sampling strategy in the *ex situ* conservation

In general, information necessary for the effective sampling scheme for *ex situ* conservation, are generally the same to those for the *in situ* conservation programs. However, the physical and financial limitations are the ones that will largely determine the type and extent of genetic variation which will be sampled and preserved in the *ex situ* conservation. Even though it is always desirable to capture as much genetic variation as possible, the total number of sampled trees must be enough in amount to make the management process possible.

In each habitat a representative sample of trees is to be sampled to make sure that population is adequately represented, however, the number of populations from which the sample is taken is also important. Sampling is to be carried out among and within populations, or among individual trees (number of seeds per tree, for example) in order to employ *ex situ* genetic conservation methods.

It is essential to define the priorities for sampling stands and trees, and have their base on information about potential genetic diversity and potential value of the material. As previously mentioned, if the gene pool is compromised, then it is very easy to make a decision: any remaining material should be sampled.

The results confirmed that two key components of the sampling strategy are the following: the size of the area to be sampled and the number of individuals to be sampled.

The sample size in *ex situ* collections. The figures in the literature range from 50 to 5.000, but that number depends on the biology, the current genetic structure of the species, and other factors related to the goals of conservation.

Sampling in different populations. Plant species and populations within species, differ at levels and patterns of genetic variation, which indicates the need for different sampling strategies to capture the maximum genetic diversity. However, prior to sampling activities the genetic structure of populations for most of the species will be unknown, and sampling heavily relies on the assumptions of theoretical models.

This problem can be addressed by information on the breeding system and population distribution.

7.3. Establishment and management of *ex situ* conservation sites

It is clear that the existing protected areas are not sufficient to achieve or maintain all forest conservation goals. Many protected areas do not have a representation of significant populations, their size is inadequate, they are well disconnected from their environment and insufficiently protected from the pressures compromising their conservation value (Kanowski 2001). Therefore, hundreds of species of trees will depend on conservation outside protected areas: in supervised forests, agricultural land, or *ex situ* in botanic gardens, arboreta, seed banks and field gene banks.

Ex situ conservation sites may have several important functions, including the supply of materials for planting and breeding programs. The transformation of the e*x situ* sites into the seed orchard achieves two goals: the conservation of genetic resources and seed production. We often assume that the traits of interest to breeders will remain constant. We do not anticipate that they will lose interest in breeding programs to improve the growth rate, but history shows that when it comes to the importance of traits, it can change. Examples of traits which were added in breeding programs include dense wood pulping process characteristics, and resistance to disease and insects. An important function of population genetic resources, whether in terms of *in situ* or *ex situ*, is to maintain variations, to ensure that new traits are included in the breeding population in the future. In addition to providing material for planting processes and breeding programs, the availability of plants in planted forests represents the research opportunities that are not possible in remote and scattered wild populations, as well as the opportunities for educating and raising public awareness which otherwise would not exist. *Ex situ* plants generate knowledge on biology and breeding. This role is crucial if we want to have knowledge on plant populations that are on the brink of extinction and to provide a basis for *in situ* management.

So far *ex situ* sites have mainly been used to provide material for planting and breeding activities, but the material which was *ex situ* conserved could have been of a great importance for *in situ* rehabilitation of habitats. There is no doubt that the next decade will increase the role of *ex situ* plantations in providing the materials for the rehabilitation of the modified and depleted forest stands, protected areas and national parks.

7.3.1. The aim of *ex situ* conservation in plantations

The purpose of the *ex situ* conservation sites is to keep genetic resources in a safe area to ensure their use in the future. However, *ex situ* conservation is rarely found in a pure form. Some botanical gardens and arboreta have a collection of endangered species, but these collections usually consist of a small number of individuals.

It is estimated that nowadays only about 100 species of trees are adequately *ex situ* preserved in the world. These are exclusively those species which genetic resources were collected for domestication programs, and which are associated with important *ex situ* activities. The purpose of certain *ex situ* conservation sites, is bound to all decisions relating to the silvicultural management of the habitat which will determine alleles and their number to be preserved, which can on the other hand be intentionally or unintentionally lost.

7.3.2. Materials and methods for establishing *ex situ* conservation sites

In "live plantations" vegetative material can be produced and plants can be grown from seed. Once they are established in a safe location and experience new environment, they maintain the gene frequency which is close to the original frequencies in the original population. Conservation sites need be big enough to (1) maintain the genetic integrity of the original population, and (2) produce enough number of seed cones or fruits, or sufficiently large pollen cloud.

7.3.3. Planning *ex situ* conservation sites

The choice of location. When planning conservation sites it is important to keep in mind two things: (a) the area needs to be suitable in terms of climate, weather and soil conditions, and (b) must be able to produce seed necessary for the reproduction of the next generation. Techniques for finding a habitat can range from simple speculation based on broad ecological similarities to sophisticated comparisons of data on similar climatic conditions and patterns. It is important to take into account the climatic similarity, such as winter and summer minimal and maximal temperatures, precipitation levels and their distribution throughout the year, the number of days in the growing season and general characteristics of the soil.

Isolation for the purposes of contamination minimization. Consideration should be given to proper isolation measures which will prevent pollen contamination, since the gene flow within conservation site, will severely reduce its conservation value. The buffer zone required for the removal of contamination will depend on the form of pollen dispersal. FAO (1992) recommended the minimal buffer distance of 330m. This distance of isolation may be higher or lower, depending on the final size of conservation units, as well as blooming characteristics, and the pollen flow.

Plantation size. The person who will plan initial phases of conservation process needs to consider the size of conservation sites in order to meet the conservation objectives. When determining the size of the plantation it is necessary to consider sampling strategies. In addition, in conservation site each family (i.e. each selected mother tree) should be represented by equal number of the offspring. Regardless the fact whether the thinning, which will take place in the plantation, will be natural or artificial, one should consider the expected drying and thinning level. All this requires multiple activities to be planned before the plantations are established. One of the key issues is related to the way of maintaining the effective population size, in other words, the way to reduce genetic variation in conservation block which occurs due to genetic drift is to be defined. Although the collection is done from trees which number progressively decreases in each generation, it is likely that if the pollination and seed collection are adequate, effective population size will remain the same after a few generations. In addition to these genetic reasons, the size of crops must be at the managed level, so that the burden of establishing and future management is within the capacity of the institution that is in charge of it. When it comes to establishing *ex situ* conservation site under the auspices of the UNEP / FAO project of forest genetic resources conservation, the minimal recommended size is 10 ha (FAO, 1985).

Access to the site. Isolation and alignment of habitat with seed sources challenge breeding and management activities in the process of successful establishment and management of *ex situ* conservation sites. When it comes to complex population conservation (ie, several *ex situ* plantations), each area has to be considered individually. There can be problems with access, maintenance, protection and safety, as well as the increased expenses. Repetitions of *ex situ* sites are vital, since the loss due to many unforeseen circumstances is likely to happen, and therefore the collaboration among stakeholders can be of a great use in this case.

Species structure. Available experiences are mainly related to the establishment of *ex situ* conservation sites with **monocultures** of a relatively well-known plantation species. For these species, many of which are pioneer species, the establishment of plantations with one species on well-known technology is the most effective *ex situ* conservation method. Information on currently available **mixed species** management is insufficient. The aim of planting more species (we use the term polyculture here) is the conservation of the major (primary) species of interest, and perhaps of others which are part of the usual ecological communities. On the other hand, species that currently have no conservation value, can be used to provide environmental conditions for the main (primary) species (eg. nitrogen-fixation plants), or the local community.

7.3.4. Establishment of *ex situ* sites

The main objective of planting trees is to establish a healthy and full-featured site. This is especially true when it comes to establishing *ex situ* conservation plantations, since planted material should reflect the same gene pool of the source population(s) it is produced from. Consequently, at the local level the best practices should be incorporated into the process of growing and producing seedlings for the plantations (FAO 1992). Methods which are more accurate and more expensive than the usual standard methods will generally be recommended.

Nursery techniques. There are several aspects which need special attention when it comes to material for *ex situ* conservation. Seed lots must be carefully marked in order to avoid any possibility of confusion and error in the identification of genotype or population. Seeds from a selected source will be collected and treated as one seed lot. Keeping the progeny identity of one tree can be useful in following cases:

- When conservation site form the basis for tree breeding programs.
- When seed "behavior" is found to be problematic (for instance, when earlier treatment differently affects the germination and genotype survival).
- Seedlings should be excluded if they are damaged or obviously infected, or if they show morphological disorder (hybrids, albino mutants), but should not be excluded due to the delayed germination or slow growth, these differences may represent a genetic variation which should be retained within the established *ex situ* sites. For this reason, the practice of seedling evaluation and planting only larger seedlings should be avoided.

Habitat preparation. The best way to ensure a high survival level - especially in climates with low amount of precipitation and a long dry season - is to carry out the complete cultivation. Preparation techniques and approaches, as mentioned earlier, should be based on the best available information about how to develop certain types of plantations, whereas the issues of site preparation are integral part of the knowledge considering the establishment of new forests.

Distribution. Individual site models should not follow any 'standard' distribution, but should adjust to species traits and to local conditions. Some general observations and recommendations that can help to make decisions include the following:

- The selected space should enable cultivation, weed management and thinning work to be done by hand or by mechanical means (FAO 1992). The number of planted specimens should be large enough to provide fully mature plantation, even if it contains some degree of degeneration and mortality due to the competition.
- Under certain circumstances, when it seems that resources won't be available for future thinning, the wider spacing can be taken into account. This could eventually lead to incomplete mature plants, but the conditions for consistent and timely management will be lower, which may increase the chances for mature plantation to succeed.
- The shape of plots will depend on the topography and the direction of the prevailing wind direction. However, to ensure adequate pollination within the habitat, the minimum diameter should not be less than 150 meters (FAO, 1992), whereas the square form is the best.

Marking the plot. Permanent and effective demarcation of sites is a prerequisite for successful conservation. Even though this may be taken for granted, there are examples of conservation plantations which have been abandoned due to insufficient demarcation. Constant demarcation can be maintained using forest roads or wide fire line, which would serve as a plantation border. Concrete, metal or wood pillars can also be used as markers, and can be considered as the most reliable approach to demarcation. One must carry out regular inspections of demarcation, and provide accurate and updated maps. Whenever possible, the physical demarcation of the field should be completed with GPS coordinates.

The identity of the individual offspring. Information on achievements of different families will be very useful when tree breeding forms the base of in the conservation sites. In cases where there is a strong interaction between genotype x environment (GxE), thinning can unintentionally reduce the genetic base. The person in charge of conservation can monitor the progeny of one individual tree and make sure to maintain the family during the thinning process (Guldager 1975). It should be noted that this type of control is feasible only with a limited number of mother trees, and it requires mapping of each tree in the site. However, even without information on individual progeny at tree level, the *ex situ* conservation is still very effective and meets most of our goals. Considering the time and resources involved in this type of control and documentation, the process of progeny monitoring should be considered only when there is a clear indication that the information provided by the invested effort will be of great value.

Weed management. Local conditions will dictate the need to remove competitive vegetation.

The complete removal of weed in its early stages is recommended in order to optimize the growth and survival of target species in the establishment phase and, more importantly, as a precaution against damage from fire (FAO 1992). Weed management ceases when canopy is formed, thereafter occasional interventions are required.

Replacement of dried seedlings. In situations where there have been a significant mortality rate within the first or two years after being planted, it should be argued whether it is necessary to recruit the plantation. There is not a threshold which determines whether to start the recruitment process or not. In each case, a person who planned conservation will have to consider whether to recruitment process will have the capacity to catch up with the rest of the plantation and to contribute to the final structure. In most cases, this is not recommended as it is likely that younger trees will remain behind and will not contribute much.

Fire protection. Adequate fire protection is crucial for the successful *ex situ* conservation. Appropriate fire lines should be cleaned around plantations. During the dry season, or when there is a risk of fire, fire lines should be “free of vegetation”. In some species, and after a certain age, incineration may be desirable. Great care is necessary, however, this method requires highly qualified staff and solid local experience.

Protection from diseases and pests. Insect or diseases attacks are to be carefully monitored in early stages. If an attack which can endanger the plant survival is identified, protective measures, respecting the best locally proven methods, should be initiated. On the other hand, information on the outbreak of serious pest problems should be considered as valuable when regarding the suitability of species in terms of conservation or utilization in this environment.

Depending on the species and the environment in which it is planted, the protection from wild and domestic animals can be of great importance in the early stages. In general, fencing and regular maintenance of fences and habitat monitoring are the most effective measures against grazing animals. However, this significantly increases the costs of the establishment and maintenance, furthermore the potential animal threats have to be considered.

Thinning. Timely thinning is particularly important for *ex situ* conservation plantations, since the reproductive potential of species may depend on them. The objective of thinning is to maintain healthy trees with good crown development, to ensure sufficient maturation and flowering activities, and at the same time maintain the appropriate size of the population with the objective of maintaining a high level of genetic diversity in the plantation. In monocultures, spacing should be based on the dominant height, implying that thinning should first be done in better, and later in poor habitats. The plantation is to be regularly monitored (every year) in order to assess the condition of the habitat in terms of thinning and development of the crown, and then to apply appropriate measures.

7.4. *Ex situ* conservation via storage and use

The aim of *ex situ* storage in tree species conservation is to maintain the initial genetic and physiological germplasm quality for as long as it is exploited or till it regenerates. To achieve this, it is necessary to take into account genetic and environmental factors influencing the germplasm during its storage process. Unlike the previous chapter, which explains conservation by living plantations - arboretums, botanical gardens, plantations and conservation plantations, this chapter explains the *ex situ* conservation through seed storage, pollen and in vitro culture and DNA's "library" of forest trees.

Bearing in mind the costs of genetic resources conservation via storage, the possible maintenance length (storage period) and the subsequent ability to use materials (after storage), it is expected that the emphasis in the first period will be placed on ex situ conservation via seed storage. For rare and endangered species, which seeds are difficult to maintain throughout the longer period, it is necessary to choose one of the other methods described below.

7.4.1. *Ex situ* conservation through seed storage 63

Knowledge on seed biology is crucial for the proper handling of seeds, including storage. Seed handling includes a range of procedures which begin with the choice of the best sources of seed, through collection, processing, storage and pretreatment for germination process. Each link in this chain involves a potential risk of seed loss, and all links in the process are equally important (not necessarily equally sensitive). If the seed dries due to the improper handling during collection or processing, even the best storage conditions will not recover it. However, the handling procedure becomes unacceptably expensive if certain loss cannot be tolerated throughout the process.

Most crops have seeds which can be dried and stored at low temperatures for years without losing the ability to germinate. This type of seed is called **orthodox seeds** (2-5% moisture), or "seed tolerant to storage", this type of seed is the most common and widespread. However, many tree species have seeds that do not follow these rules. They are difficult to store because they do not tolerate drying and are therefore called **recalcitrant seed** or non-orthodox seed (12-31% humidity) or "seed inintolerant to storage". Other seeds that do not fit into any of these categories are referred to as **intermediate seed**. In reality, the differences between species probably range from very tolerant to very intolerant seeds. From a practical point of view, there are two factors that are of great importance for seed storage: seed moisture content and storage temperature.

Orthodox seed storage. Storage of orthodox seeds is a common method in *ex situ* genetic resources conservation of plants. Techniques include drying seeds with low moisture content (3-7% fresh weight, depending on the species), and storing them in airtight containers at low temperatures, preferably at -18^{0}C or colder (FAO / IPGRI 1994). In this way the seeds of many orthodox species can be kept for several decades, and perhaps centuries.

Recalcitrant seeds storage. The seed that has a relatively high water content (>40-50% of fresh weight) is not able to withstand desiccation and is often sensitive to cooling process. Therefore, this seed cannot be maintained under conventional conditions of storage and is described as recalcitrant (Chin 1988). Even when stored under optimal conditions, its life is limited to weeks and sometimes months.

Recent research work identifies species that show **intermediate** behavior in terms of storage. The term is used to describe seeds which tolerate a greater degree of drying than recalcitrant seeds do, but they are less tolerant to drying than orthodox seeds (Ellis et al. 1990 1991). Additionally, this seed is often sensitive to cooling process. Since the sensitivity to constant drying in high sensitive species and in relatively tolerant ones was observed (Berjak and Pammenter 1994), the long-term preservation at -20^{0}C may be impossible, as it is possible for orthodox seeds.

7.4.2. Cryopreservation of seeds and seedlings

This term refers to the seeds that are stored at very low temperatures, typically in liquid nitrogen (-196^{0}C). Together with the *in vitro* culture, this technique is often the only safe and economically justified choice for storing unorthodox species. In cases where the seed is not subject to cryopreservation, separate embryos or embryonic axes are to be used.

Cryopreservation techniques of seedlings are related to conservation of young seedlings which growth was stopped by storing at low temperatures and / or under low light intensity.

7.4.3. *In vitro* conservation

This conservation method maintains explants in a sterile environment free of pathogens, and is widely used for the conservation of species which produce recalcitrant seeds or do not produce them at all, or for vegetative transmitted material to maintain certain genotypes (Engelmann 1997). Although the research work on *in vitro* techniques began several decades ago, this technique is used for copying, storage and collection of germplasm material for more than 1.000 species (Bigot, 1987).

In vitro techniques can be effectively used for the collection, storage and reproduction of problematic species (Engelman 1997). Also, in cases when the seeds of the selected species cannot be collected, or the bud quickly loses viability, the establishment of aseptic culture in the field will enable the collection. The plant material with a high level of duplication can be propagated in aseptic environment via tissue culture systems, such as in vitro somatic embryogenesis.

A variety of in vitro conservation methods can be used, which will depend on the required storage period (Engelman 1997, Withers and Engelman 1998). For short-term and long-term storage, a variety of techniques are designed to reduce growth and increase the intervals between subcultures.

7.4.4. Pollen storage

This technique can be compared with the seed storage, since most pollen can be, based on dry weight, dried to less than 5% moisture content and kept below 0^0C. Some species, however, produce pollen of recalcitrant storage type. There is limited experience when it comes to survival and capacity of the cryopreserved pollen which is over 5 years old (Towill 1985). Pollen has a relatively short life if compared to seed (although this varies considerably between species), and longevity tests can be time consuming and complex. Despite the fact that this is a useful technique for species which produce recalcitrant seeds (IPGRI 1996), pollen storage has been used in a limited extent, mainly for the germplasm conservation (Hoekstra, 1995). Small amounts of pollen which is produced by many species is another disadvantage. On the other hand, pollen rarely transmits diseases and pests, with the exception of some viral diseases, allowing safe movement and germplasm exchange.

7.4.5. DNA storage

This method of storage is rapidly increasing. DNA from nucleus, mitochondria and chloroplasts are now routinely extracted and immobilized to nitrocellulose sheets which can be tested with a number of cloned genes. These advantages have led to the formation of an international storage network of DNA (Adams 1997). The advantage of this technique is its efficiency, simplicity and small space consuming. The main disadvantages, in addition to the requirements for the extension of capacities and equipment, lie in subsequent gene isolation, cloning and transfer. The obvious problem poses its inability to regenerate the whole plant (Maxted et al. 1997).

7.5. General guidelines for *in situ* and *ex situ* forest genetic resources

conservation

When one is faced with enormous need for the conservation process and a lack of knowledge, one might wonder where to begin. Actions based on the principle of systematic and robust approach may be more effective than waiting for the elusive information survey. The systematic approach is essential in initial stage of the debate on the priorities using familiar facts and anticipated threats to forest genetic resources. The solution is sometimes to be found in the use of resources in a different way, or giving it a higher value, which can paradoxically imply a higher degree of efficiency.

Conservation of strong and productive population of trees is a fundamental requirement for the management of forest genetic resources. This is particularly important when considering common biotic and abiotic threats to forest trees which have been going on for decades, and especially important if rapid climate change and global warming occurs. I*n situ* conservation plan could be, whenever possible, integrated into the process of natural forest management. Management guidelines intend to help the person who manages the forest to recognize the value of genetic diversity as an important resource for sustainable production. At the same time, large areas of forests that are managed will help preserve genetic resources which can be sampled in a network of protected areas.

Sustainable management cannot ensure the conservation of forest genetic resources itself. There are species and populations which need special and immediate attention, as well as many species of no or very little current value, and are likely to stay unmanaged. Some of the less known and less economically important species may be damaged by complex ecological interactions. Thus, an integrated approach which includes the management of natural stands and the establishment of special conservation population is something one should strive for. The current system of protected areas is often a valuable starting point in creating a conservation network of certain species habitat.

Since the strategy of forest genetic resources conservation primarily focuses on issues relevant to their conservation in natural habitats, it should keep in mind that *in situ* conservation is technical ability only in a broader approach to conservation of diversity among species and within species. In some cases, the *in situ* conservation of forest trees is the only socially and economically possible way. In other cases, a combination of protected areas, reserve management, clone banks, research plantations and breeding programs may be suitable for different conditions and objectives.

Ex situ will continue to be an important part of the maintenance and management of forest genetic resources. They cannot cover all aspects of the gene conservation process via one approach - each has to be evaluated in relation to the objectives of conservation, biological limitations and organizational limits.

8. SUSTAINABLE FOREST MANAGEMENT OF FOREST GENETIC RESOURCES

Sustainable forest management is a multi-purpose forest management, which aims to ensure that the capacity of forest services and products are provided, not decreased over time (FAO 1993). It involves the employment of forest management practices which allow the use of wood and other forest resources, a sustainable use for the nation development and for the benefit of human communities living in or near forests. Sustainable forest management and conservation of forest genetic resources are interdependent. Many of the selected species are not adequately represented in protected areas, or included in the crops and domestication programs. Consequently, the alignment of objectives of conservation and management as well as practices in production forests or multi natural forests, is essential for the conservation of forest genetic resources of these species. These factors also underline that economically productive forest ecosystems which are under the management process, play a central role in the conservation of forest genetic resources. A continuous process of forest genetic resources conservation, which is a large scale process also, can be achieved only by integrating the conservation and possible problems in the practice of the management of production forests.

The main objective of sustainable forest management will ensure that vital populations intended for the cultivation of major commercial species, and species that provide non-timber forest products to local communities are maintained. Sustainable forest management must take into account the relationship among animal pollinators and seed dispersion of commercial and non-commercial tree species.

8.1. Management systems of forest genetic resources conservation in different types of forest

The majority of mature trees are mostly harvested during the selection logging (of any variant). This is possible because there is a high percentage of commercial tree species in natural forests, especially those that are under long-term management. Most gene conservation criteria are met, if the domination of local regeneration is allowed, and if the population size and enhanced gene fluctuations to the adjacent stands or plantations are respected. When it comes to the management objectives of forest genetic resources in different types they are same: **to provide an adequate level of regeneration and strengthen the local seed sources** in appropriate genetic or environmental variations.

A detailed management plan requires a significant amount of available information, such as inventory of current stocks and their condition, age, structure, and the soil evaluation, slope, and other factors which affect the way silvicultural and logging measures will be employed. Detailed information on the forest structure and its growth is vital, both for the sustainable production and genetic conservation. Essential information is based on inventories, such as botanical research before harvest inventory, research on regeneration and information on non-timber forest products. Since there is a lot of information in literature on botanical research methodologies for different purposes (Mueller-Dombois and Ellenberg, 1974, 1989, Kent and Coker 1996), accordingly, management plans and the selection of appropriate silvicultural systems are to be defined in the line of those information.

The inventory prior to harvest, should inspect and assess the number of the current level of plants (offspring), seedlings, and the growth of market demanded tree species, as a base for logging activities in the future. This inventory will generally involve detailed sampling within the small lot, evenly or systematically distributed throughout the area. The percentage of sample areas will depend on factors such as the level of available resources, the site heterogeneity, regeneration category (e.g., sampling may consist of a single sample plot of 10x10m, all seedlings / plants below the determined breast diameter are counted). Simple approach can represent both the qualitative and subjective assessment (rough classes which may correspond to a certain seedling density) of seedling regeneration of species which are commercially important and easily recognizable.

In addition to estimating the harvest volume, sustainable yield and natural regeneration, forest inventory should be planned and designed in a way to provide basic information for continuous monitoring. This will include the establishment of permanent sample plots for continuous forest inventory. This information can be used to explore the implications and impacts of various logging and silviculture measures.

An important step is to develop a management plan to achieve desired goals. The objectives of the genetic conservation should be an important element in the management plans for forest production and multiple uses, in order to ensure their future productivity (reasons defined in the previous sections). They are essential if a forest is defined as a part of a network of selected conservation priorities. Also, the management plan should set requirements which contractors will have to meet when performing logging operations. In order to limit damage to the remaining trees in the forest, the number, type and size of trees are to be determined.

Sustainable timber production and conservation will depend on the selection of appropriate silvicultural systems, especially on the mode and logging intensity, such as the selection of one tree, or a group, clear-cutting will have to meet the requirements of major commercial species regeneration. Selection of appropriate silvicultural systems and practices that will enable the renewal and regeneration of important tree species, require a good understanding of ecology of any species. Where there is a lack of such information or where in mixed commercial species stands vary in their requirements, different system of governance that will promote diversity in different parts of the forest is to be employed. In addition, the use of different management systems can increase the variation among the managed units.

8.1.1. Harmonizing logging activities with forest genetic resources conservation

The management of timber production carries the risk of local endemic species extinction, especially of those which are sensitive to physical habitat disturbance. Harvesting is currently the only measure in many of our forests. However, this measure can reduce the volume of economically valuable species, especially of high value ones. The zoning process within managed forests, where different management regimes and measures are employed, can significantly reduce the impact of harvest on forest biological diversity. One cycle of selective logging will not reduce species richness among populations of trees, if adequate growth is ensured and major damages during the harvest avoided, or if the seeds for future regeneration becomes available in the soil or in adjacent areas. Impact of harvesting on forest genetic resources will depend on several key factors:

A. The intensity, frequency and time of harvest

B. Procedures to determine which trees will be harvested or preserved

C. The level of planning, including the use of special conservation measures

D. Harvest implementation

E. Regeneration system

F. Management after harvest.

A. The intensity, frequency, and time of harvest

Two broad categories of a logging system are monocyclic (clean) and polycyclic (selective). In monocyclic systems all trees are harvested at the same time, at the end of the rotation (from the point of direct conversion of coppice forests this activity draws attention in our country). Long-term productivity and conservation of genetic resources of these forests will depend upon their regeneration capacity.

In most cases, the activity of logging in productive forests should perform the formation of gaps related to the regeneration of the selected species. Widespread clear logging has a negative impact on the environment, including the erosion and degradation of fragile lands, spreading weeds which hinders forest regeneration and increases susceptibility to a fire.

Accordingly, polycyclic or selective logging system should be in general use (where possible). Even though it sometimes seems impractical, the best time for harvest in forests managed by this logging system is after seed maturation and its dispersion. This is especially true for tree species which seed cannot be stored for a longer period of time, and where the research work have been done before harvest showed the low representation of seedlings.

B. The procedure for selecting trees for harvest activities

The critical factor in selection logging for any type of forest means that there is a balance between harvested trees and the forest growth. The actual logging will be based on the continuity of sustainable yield and income. In most logging operations, the standard procedure to determine which trees will be harvested pay attention to the following:

1. Particular commercial species.
2. The limited logging diameter size - it will depend on the species.
3. Tree location within the habitat to implement the most cost-effective logging plan.
4. It is necessary to create regeneration gaps of appropriate size and distribution.

Positive selection of trees in silvilcultural activities indicates intentional removals of trees which slowly grow, are poorly formed, diseased or damaged by insects, so that for the next generation are kept the healthiest and best-fitted individuals.

The practice of selective logging by the limited diameter, which leaves behind the worst trees to produce the next generation, is called the negative selection of trees in silvilcultural activities. Such practices are likely to have an adverse effect on future generations by increasing the presence of undesired genes.

The following guidelines for the selection of individual trees for logging operations will help to ensure the long-term productivity, and conserve forest genetic resources at the same time:

• Whenever possible, apply the positive breeding selection. In mixed forests, and where economic factors allow, maintain high - quality phenotypes of the species which appear to be the most wanted during the first logging operations.

• Avoiding negative selection of trees in silvilcultural activities and all forms of ranking, including (a) a highly selective logging or operations which consider logging trees of a suitable size, and of a high demand species in the market, and (b) in even-aged forests avoid the tree harvest which is based on the limited size diameter.

• In cases where phenotypic superior individuals of most wanted species intersect, one must make sure that their offspring is adequately represented in the existing regeneration activities or in the seed bank.

• Quarantine of rare and highly endangered species due to the logging activities, especially of high value commercial species. In addition to assisting the conservation of the biological diversity and genetic resources, such measures also aim to increase the representation of species which will again be economically exploited in the future.

• Minimize logging and indirect damage during the harvest, to ensure the adequate number of mature individuals of each species after harvest.

C. Planning the logging process

The maintenance of forest genetic resources reduces logging damage to trees and keeps regeneration process at a high level via planning and protection activities performed by qualified staff. Poorly planned and organized logging operations cause damage between 30 and 60% of the remaining trees. Logging damages are also closely related to the intensity of logging operations.

Key guidelines relate to:

• methods for the construction of the skidding roads;

• tree selection and their marking;

• directional logging methods

• damage assessment after the harvest.

D. Implementation of logging activities

Well-trained forestry experts should prepare detailed plans to achieve their goals, which will be applied by well-trained managers. A high level of care and concern should be maintained during the logging and skidding operations, in order to minimize environmental damages, especially to the increment and regeneration capacities of commercial seedlings, and land protection as well.

E. The choice of appropriate regeneration methods in pursuit of the forest genetic resources conservation

Natural regeneration. Natural regeneration is generally the cheapest regeneration method which can meet the objectives of genetic resources conservation. In addition to maintain the adequate number of individuals which will replace harvested trees, the large regeneration of the natural offspring will eliminate inbreeding and other forms of the genetic load (the accumulation of harmful genes) at different stages of the tree life cycle, especially in seedlings and plants at an early stage in which natural selection occurs.

The two most important factors to prompt natural regeneration and desirable wood species are:

• To create a beneficial light regime or gaps. Suitable niches / gaps for regeneration will be mainly achieved via appropriate cutting regimes.

•To carefully plan and implement the logging plan to avoid the damage to natural offspring. This is particularly important for species which seeds cannot be kept for a longer period.

Artificial regeneration. In some cases, stands are restored artificially, or their natural regeneration is assisted with the assistance of local seeds or seedlings.

Generally accepted guidelines:

• Collecting seeds / seedlings from the appropriate number of trees, preferably more than 50, which are scattered throughout the area which is to be restored.

• Collect fairly equal amount from each tree, or at least avoid having several trees to be represented by larger quantities of seeds. Keep the seeds away from trees during collection and transport, mix the seed just before sowing in order to provide the reasonable seed representation.

• Collect seed in those years when flowering and ripening are intensive or massive, in order to increase the odds of high level outcrossing and maintain higher representation of trees that which up the parental population.

• Collect seed throughout several different periods to ensure greater representation of trees that make up the parental population when it comes to those species which flowers and fruits sporadically mature during the year or a longer period.

• If there is a large number of available for the seed collection, then they can be used to introduce a higher level of phenotypic selection, and to collect seeds of better phenotypes, e.g. better shape, the absence of spiral grain, etc.

F. The management process after logging activities

Different types of measures are often required to restore the forest after the logging. Such measures can be the following:

• improve the vegetation cover around the harvested stumps,

• close logging roads to keep people away,

• assess the current situation after the logging activities and estimate the achieved restoration level,

• additional restoration measures and

• cleaning (gradually removal of new weeds / early secondary species that overshadow desirable species).

Generally speaking, a well-planned and carefully implemented harvest, can be used to maintain a balance between the different stages of ecological succession and to ensure the maximum genetic diversity and conservation of genetic resources of tree species in different successive stages.

8.2. Monitor and evaluate the impact of management practice on forest genetic resources

Careful monitoring and follow-up activities in the forest, should ensure the implementation of the designed management practices and achieve the desired results in species structure and age / class structure, and the levels of genetic variation in a species which are in the focus of the management.

The proposed model of "conservation processes which maintain genetic variation" is the only criterion for maintaining the sustainability in forest management practice. Various genetic indicators were identified as essentisl to maintain the sustainability. There are two types of verifiers for each indicator. As far as demographic (including environmental) verifiers are concerned it is necessary to conduct field research work, including the population study (the number of individuals of different ages / sizes or reproductive classes) and reproductive biology and ecology studies, as well. When it comes to genetic verifiers, it will be necessary to study molecular markers, as well as long-term field research work carried in the field /laboratory on quantitative and adaptive traits.

Demographic verifiers are likely to be used by those who manage forests, as they provide important information regarding the management. In this case it is not necessary to have contacts with geneticists, trained technicians or specialized laboratories. Managers have to choose the most appropriate demographic verifiers according to the resources and needs. Verifiers to be easily assessed are:

• the number of sexually mature individuals,

• age / size shift class and

• germination (tests that could indicate the increased inbreeding).

The collected demographic, genetic and ecological information should be tested and specify whether some of the perceived changes as part of a natural cycle or management practices could be changed in order to ensure the genetic resources conservation of the managed species. This review and analysis is to be done in collaboration with a forestry genetics specialist.

The following procedure can be used to determine the sustainability of management in terms of conservation of genetic resources:

Step 1. Documentation and species mapping within the forest management unit (FMU) - in our circumstances it may correspond to the category of the management class.

Step 2. In cooperation with environmentalists identify those species which are likely to be the most vulnerable to the negative impacts of interventions occurring within the "FMU". These species should be identified on a regional basis to make the comparison between forest management units easier. 73

Step 3. Assess the most appropriate species for each intervention by using environmental verifiers, and if there is a need for more precise details use genetic verifiers.

Step 4. Combine the information collected in the previous step to obtain a comprehensive assessment of the sustainability capacity. Even though juvenile trees of selected species are present, the manager may need to consider the possible lack of sustainability in relation to:

• Directional changes: whether the selection occurs, for example, in favor of trees which have a weaker tree form, early flowering phase or other traits?

• The population size: that a new generation is based on the offspring coming from only a few trees?

• Migration: whether the pollen and / or seeds is (still) scattered throughout the area, or whether management practices limit the gene exchange to a great extent?

• Reproductive system: whether the trees are in a flowering phase and produce seeds?

Step 5. If any species in step 4 is found to be unsustainable, a modified and more intensive monitoring is to be adopted.

8.3. Management of other (non-wood) forest products

Other (non-wood) forest products (NWFP) are defined as goods of biological origin other than wood derived from forests, other wooded land and trees outside forests (FAO 1999). They include a wide range of products, for example: plants for food and for medical purposes, fungi, fibers, coloring agents, resin, rubber, animal food and other supplies. The collection of these products can strengthen the sustainable management and conservation of forest genetic resources, by providing a direct benefit to people living in or near forests (FAO 1993). However, all these issues are very complex, they often involve different socio-economic and environmental aspects which altogether affect the final outcome.

Once it is well-planned and carefully integrated, the traditional collecting of non-timber products carried out by local residents, is generally compatible with forest management of timber production and conservation of forest genetic resources, and the other way around.

Extraction of non-timber products can have far-reaching consequences to the environment, as well as negative effects on forest genetic resources. Such situations usually involve commercial extraction, including the extraction carried out in areas away from the production area, and not the activities important for survival / traditional use.

Threats to forest genetic resources which come as a result of the use of non wood products can develop very quickly. In cases when the whole plant is collected, the effects of the size population reduction may be genetically significant. When it comes to smaller populations, considered as particularly valuable species as well, the whole population may already be lost or depleted by excessive exploitation of non wood forest products. The collecting of the reproductive structures - flowers, fruits and seeds - will directly reduce the effective size of the reproductive parent population and reduce genetic diversity in subsequent generations. In such cases, the collecting activities mainly focusing on better genotypes may cause the population to be dominated by trees of marginal economic value, and of lower value as a genetic resource. Of course, in cases where a high percentage of flowers and / or fruits of certain species is collected on the regular basis, the most important long-term environmental and genetic impact will be the reduction of the regeneration capacity and the number of seedlings, which can lead to the population extinction.

The text above provides a lot of information and useful examples of extraction of non-timber forest products from multi-purpose forests:

1. Local participation: the use of non-timber products from the forest areas should be agreed with the local community through a participatory and consultative approach. It will be necessary to define which products can be extracted (including by whom, when, how and the number) and protected.

2. Focus on non wood products that can be produced on a sustainable basis from natural forests, or products that do not require the destruction of the whole plant, vital organs or excessive use of reproductive structures.

3. Focus on a variety of non wood forest products for local use: for a given forest area the most sustainable way to use non wood products include traditional harvesting, accompanied with some intensifying activities for local sale, a wider assortment of species' products.

4. Market-oriented use of non wood forest products focuses on species which can be efficiently produced and managed in natural forests. It should be kept in mind that these same traits will make them more suitable and attractive for domestication and the development of commercial plantations.

5. Monitoring and management measures which will ensure sustainability and increase, or at least maintain the participation of non wood products in forest ecosystems.

8.4. Breeding and conservation of forest genetic resources

Breeding trees reflects the results of the evolution process which aims have been set by man according to his needs and goals. The breeding process is based on the directed utilization of genetic diversity through the selection process, a realignment of its desirable characteristics with the process of conserving individuals possessing these traits. Additionally, breeding strategies and breeding methods are to be defined here. Breeding objectives aim to the production of the adaptable reproductive material which will produce high-quality individuals.

Tree breeding techniques such as modern selection, breeding and selection methods are, of course, important in efforts to improve the economic and environmental traits that are of interest. An important technical development in tree breeding, which has recently been developed, focuses mainly on the effective formulation of the field experiment, the principle of effective crossbreeding of the advanced breeding generations, and many other specialized techniques and tools to assess the traits of the economic or environmental interest. It is believed that the selection programs, breeding and testing represent the simplest and most effective methods to be employed by an organization to meet the objectives of conservation and breeding processes within the rational time frame. In most cases, only one generation of selection and testing can fulfill the majority of goals, enabling the program to carry on with the next important species.

In a near future the forestry will be more and more pushed to the land of poor quality, due to the growth of the global population and the increasing agricultural demands for high-quality land, and the conversion of land to urban areas as well. It will be necessary to find species and populations of trees which will adapted to these marginal habitats. Testing species and provenances, pre-breeding programs or improvements will aim to produce different populations of trees which can adapt to different climatic and soil conditions. New dimensions of planning and management of forest genetic resources will have to be developed. The only way to achieve these is to access a wide range of genetic diversity, with relevant information on species distribution, patterns of genetic variation and critical understanding of the biology of species. In that sense, the research work will continue to be an important part of our ability to manage forest genetic resources in the future. When it comes to species which can be involved in a research work, whether in terms of molecular genetic experiments, or interspecific field experiments which will develop some good pre-breeding or breeding options, we may need to focus on yield maintenance or wood products, rather than to the conventional goal of improving and optimizing yields. For example, the marginal improvement of some traits, such as survival or resistance to pests, may be more important than the increment improvement.

8.4.1. Providing the potential for the future use

Current selection processes are based on the features which modern society considers as necessary. However, the development of science and technology will recognize the importance of others, now uninteresting species, populations or individuals. The conservation process will ensure the survival of these categories, and thus their potential for the future use. Nowadays it is necessary to have a broad genetic basis in the breeding process, which should be provided for other individuals, species, populations or species which potential has not been recognized yet.

9. RESEARCH AND DEVELOPMENT

The current situation of research work on biodiversity in the Republic of Srpska is very poor. There was not any systematic research work at the end of the 19th and the early 20th century in this area. Some sporadic research work, mainly in a narrow geographic area was conducted, so it is hard to find information on the number and distribution of species in flora and fauna.

The available information for most species is very limited even when it comes to basic biology. Having in mind the fact that there are numerous tree species of current and future economic potential, it seems impossible to go further than guessing their basic biology and genetic structure (FAO, DFSC, IPGRI. 2001).

For this reason research activities are critical in filling the gaps when it comes to the lack of information. In fact, research activities are expensive, time consuming, and often limited to a few species and their populations. The main question which is critical to initiating the conservation process needs to determine the types of genetic studies which can provide important information, thereby improving the conservation process. We need to set priorities and to identify strategic actions that will have major impact.

9.1. The importance of specific studies for practical conservation programs

Even though the priorities have been chosen, there are still many issues to be addressed in many conservation programs. Research can contribute to the decision-making process, especially with regard to the following issues:

- The exact location of the remaining trees - the populations of selected species, and what is their conservation status?
- The number of populations necessary for the gene conservation (one, a few or several)?
- Which populations (locations) should be protected (or the basis for the collection of seeds that will be subjected to *ex situ* conservation process)?
- How big should the conservation unit be?
- How to manage the conservation areas?
- What are the forms of tree reproduction in *ex situ* conservation?
- Which species are exploited, and how to combine the exploitation and conservation processes?

The study, which may increase the likelihood of making the "right decision" - a model and implementation of a successful protection program - should be involved in global activities. Although there are many fundamental biological and genetic processes that need further study, it is best to leave them to be objects of research programs with a long-term funding, which will address the basic research work on biological processes.

In pursuit of the better practical impact on the conservation of specific genes:

• The study should be economically and technically feasible. Since there are many species which have not been explored and a limited number of resources, a wise decision on resource exploitation should be made.

• Results are to be well-timed. Even though there is an urgent need for action, few years have to pass to make the initial decision.

• It must be expected that any new information will have an impact on the planning and implementation of conservation activities, in other words, it has to increase the odds for the conservation program to succeed.

The obtained information can be used for the purpose of a deeper understanding and describing the genetic variation in species. However, in some situations, it must be decided whether the limited financial resources are to be allocated to interesting research programs, or to field work within the conservation process. The role of research work on gene conservation programs is comprehensively addressed by FAO (2002).

9.2. Where are remaining populations, and what is the current conservation status of selected species?

In most cases, it is necessary to carry out some basic research work in order to locate remaining populations, estimate the number of populations, and to study the population dynamics and monitor threats. If the goal is to conserve species and its representative ecosystem, these studies will provide basic information about the changes which need to be monitored.

When all the basic information are collected, the next step is to design the standardized sampling methodology for the research. Since there is a large number of different sampling techniques, it is important to choose one that will contribute to data collection best. Demographic surveys form the basis of any conservation program of endangered species. Making records on habitat will contribute to our knowledge when it is necessary to define the beneficial habitat for selected species in cases where this type of information is missing or is not sufficiently explored, as is the case with many rare species. Observations on the general ecology of species are of great importance for the species conservation. For example, species may be protected, but if there are not any factors such as pollinators or animals which disperse seeds, conservation efforts will probably fail.

Once the information is collected from the field, it is not easy to "transform" and instantly show the conservation status. There are many factors that affect the conservation status, however, any system which uses these factors to measure and eventually compile a list of priorities will have to pay attention to the amount of knowledge about the reproductive biology and genetic structure of the species.

It seems ironic that genetic information might not meet many of these goals. Even without genetic studies, which provide us general information about genetic variation within and among populations, we can be sure that genetic variations, within and between populations, will be distributed that at some level. Therefore, the sampling activities are to be done at the population level, in order to get a good picture of individual copies of the selected population.

9.3. The research work which should assist the decision- making process about conservation populations

In most cases the genetic variation among populations is rarely known before taking any conservation actions. Most of the selected species often grow in changing environmental conditions, and / or are distributed over a large area. Therefore, it is advisable to keep a large number of populations which represent different parts of the distribution area. Of course, there is a limit to the number of populations which can be efficiently processed. The question is the extent to which populations differ and have different traits. If differences among populations are smaller, then the conservation program should include a small number of populations.

It is recommended to take into account the fact that certain species developed other genetic differences due to natural selection caused by the long-term exposure to some selective forces (such as drought or cold). Genetic differences may also be created among small populations which have been genetically isolated from one another for a longer period (eg, Serbian spruce). On the other hand, factors such as different history of species introduction and migration can also cause populations to be genetically different (via genetic drift - random fixation). In this case, conservation should rather include a larger number of different populations (networks), than one larger population. However, the conservation program can not include all populations, therefore, two questions arise – the number of populations to be selected for this process, and after the network size is determined - which populations are to be included in the conservation?

The test which is frequently used to determine the origin, and which represents an informative technique for the study of genetic samples, is the application of quantitative traits, such as survival capacity, height, diameter, tree shape and the flowering / fruiting. A large number of studies based on DNA genetic markers, which ensure a rapid examination of genetic variation within and between populations have recently emerged and rapidly developed (Gillet 1999).

For practical purposes, the first priority in research is to assess the trait variations referring to the fitness of the each individual, and not the results from the study of genetic markers such as allozymes or DNA markers. Studies of genetic markers are cheaper and simple, the information can provide a good base of the population structure and may affect the choice of the sampling approach. However, tests which are used to determine the origin (and most quantitative genetic studies) have some drawbacks:

• The results will be available in a few years.

• The results of some experiments may reflect the growth under certain conditions.

The implementation of a study which is based on genetic markers should be careful, unless it is combined with the observation of quantitative traits such as growth and survival capacity. Studies of genetic markers provide potential information on the relationship between populations that have emerged due to the limited gene flow among small populations, or as a result of different migration routes. Such information is a useful background for the interpretation of the results obtained in field trials. General crossibreeding level of closely related plants and genetic diversity can be estimated on the basis of molecular marker analysis.

9.4. How large should the conservation unit be?

Much attention is paid to the genetic processes that are associated with small populations. It is known that the conservation units do not have to be small, since the genetic drift and the increased inbreeding level cause the continuous loss of genetic diversity. There are so many guidelines which take into account various aspects of these processes, and address the effective number of trees that should be included in population conservation.

In summary, the literature suggests that population size can vary from 50 to 5.000, which of course depends on the conservation objectives. As previously mentioned, the lower limit of the recommended number (50 +) targets on quantitative genetic variations (*ex situ*) objectives, and tries to preserve the basic levels of genetic variation. From a practical point of view, the number of 5.000 selected trees, opposed to 50, could employ a completely different approach for the conservation process. There can be various genetic approaches that could lead to a more precise determination of the population size providing a clearer picture of the biological targets for each approach during the course of the research work. When it comes to the crossbreeding of plants which are closely related, it is proposed to have a population of about 50 trees, however, if it is determined that cause lies in this crossbreeding process, this number needs to be much higher. Maintaining genetic diversity "in the long run" by balancing between genetic drift and polygenic mutation, has led to the recommended number of about 500-5.000, nevertheless, these numbers greatly depend on the expected rate of polygenic mutation. It is not only hard to accurately estimate these parameters, it is also an expensive and time consuming process, and therefore rarely available in most of the conservation program.

In practice, the number of trees is to be assessed based on the estimated size of the protected area. For this reason, it is necessary to have the information on the approximate number of mature trees per hectare, which can differ among species and among populations. In fact, when the long-term survival for selected population is to be secured, demographic, and environmental factors can be as important as genetic processes are (Shaffer 1981; Lande 1988). Environmental modifications which affect the abundance of pollinating vectors (Bawa and Hadlez 1990; Owens, 1994), or microclimate changes which are necessary for successful natural regeneration (Graudal et al. 1995), present important factors which maintain populations of trees at the level of several generations. These factors are more or less related with the area, because it is necessary for the suitable environment - as well as all interactions with other species – to have a conservation unit which is one hectare in size. In a case of densely distributed species, if the forest is genetically pure there will be more trees than necessary in such a large area.

9.5. Information and research work which support the development of guidelines for the management and the use of conserved populations

Human activities in forests which are included in the conservation process, can have genetic implications, and can be in conflict with conservation goals. It is obvious that the research work should define suitable forms of use, that is, to determine the management type.

Changes in species structure and microclimate caused by logging which reduces the number of their pollinators can reduce the reproduction capacity of those trees. The harvest of lower density species can also increase the average distance between two trees of the same species, to the extent in which the interbreeding is not possible. The reduced interbreeding capacity can pose a serious problem for many species, especially since it can reduce the fertility. Changes in the interbreeding level after harvest, can be studied by genetic markers, or the interbreeding level can be assessed over a longer period.

Selective logging of high-quality trees can cause genetic selection of species which have low economic value and a weak tree form. Possible effects of selective logging depend on the capacity to inherit selected traits (Falconer 1989), and the manner in which the selection process was performed. In natural populations, where there is a mixture between species and age of trees, the inheritance is probably low for traits such as growth, while it is higher when it comes to tree forms. Since the genetic response is expected to be low in moderate selection, serious forest degradation will cause faster and important genetic changes and reduce the commercial value for future generations (Ledig 1992, Savolainen and Kearkeainen 1992).

Heritability and traits of the selected species can be evaluated via field experiments, where the offspring are grown and compared. This is usually applicable only for species which are grown in the plantations, and - as they require time and resources - such studies are only available for higher priority species. For most conservation programs, information on the heritability of selected traits would be desirable but not essential.

A strong negative selection (of high-value tree logging) should not be present in the areas included in conservation process. Before we start the experiments in the field, it is important to note that the results may not be available for several years, or even longer. When activities such as conservation and use are combined on larger areas, these types of study will be important.

Although it is often important to combine the utilization and conservation of trees, the internal utilization of many species has genetic implications. Seeds that are used for the reproduction of species collected in the vicinity of farms, parks or from a small number of trees, can cause strong genetic implications, especially when it comes to the interbreeding. The overview of sources (roads) used for the seed purchase is one way to determine the origin and the distribution of the germplasm. These findings may represent a starting point in designing strategies for the sustainable management of genetic resources in newly established forests.

Important selective processes may be involved in the process of propagation and cultivation. From the conservation point of view, it is also interesting to know to what extent different traits genetically correlate. To evaluate these correlations, it is necessary carry out experiments with the offspring, however this information will be available only for species that are currently in extensive utilization and of a high value.

Many species have not been planted yet, although they may have great potential for planting. The utilization of these species, as part of an integrated use and conservation plan, may require research work on their cultivation options. Such studies may focus on the problems that are associated with the purchase of seeds, plant production, establishment, processing and / or use of the product.

9.6. The application of molecular studies in the conservation of genetic resources

Molecular genetic studies, conducted in many forest trees species worldwide, contribute to a better understanding of patterns variation in order to develop improved management practices, and to monitor changes in the species trade. In some cases, these priorities can be redefined using new tools such as molecular markers and model simulations. Integration of GIS tools with molecular research will expand our knowledge of the genetic diversity of landscape models, the distribution of species, as well as help to develop plans for resource management. Molecular methods can also assist the identification of differences between local and non-local provenances and genotypes, define the biodiversity loss and facilitate the introduction of new options for integrated conservation and breeding programs. This can also provide the insight into the genetic variation within a species (Brown and Kresovich in 1996; Karp, 2000).

Nowadays, the use of a wide range of molecular markers affect the required (expected result) by choice on selection, mode of application and their interpretation.

9.7. Where to put the focus in the research work?

Even though it is important to have decisions about genetic conservation based on genetic understanding, it is important to note that this is not a prerequisite for the action. In most cases, the conservation process of forest genetic resources is necessary in to involve representative population from environmentally representative or different areas, as well as to include the overview of the conservation status of different populations. Of course, genetic research per se, is of great importance because it can enhance the understanding of genetic processes and thus improve the general concept, selection of specific populations and management activities. Forest genetic research is useful in capacity building and training geneticists, who can understand, promote and conduct the field work. It is necessary to carefully consider the role, the specific conservation goal and potential impact of each genetic studies which can be applied.

10. A COMMON APPROACH IN PROGRAM ADOPTION AND IMPLEMENTATION

People's participation in developing projects is essential, as well as in the process of natural resources conservation, including forest genetic resources. First, it is useful to think that participation is a process of communicating and working with different people and groups, in pursuit of achieving a common goal. Conservation of forest resources requires interested parties to trust each other and to commit themselves to the task of sustainable use. It takes time to develop mutual trust; especially if stakeholders do not have previous experience in decision-making and management processes. People who are in charge of planning and other interested parties can do a lot to strengthen confidence by listening to ideas or complaints in a way to expresses respect and appreciation. Conservation activities should be organized in a way which will enable interested parties - especially those with no previous experience in participation – to gradually undertake task by task, and progressively build trust.

Natural resource management has increasingly become social and political objects of struggles between different groups seeking rights over certain resources. Conservation of forest genetic resources is now impossible unless technical expertise include political and cultural standpoints within which the conservation is going to take place. The participation of local population has recently been more and more welcomed in achieving the effective conservation of protected forest areas. Participation in the conservation of forest genetic resources is often associated with the concept of municipal forestry. The municipal forestry implies that forests are managed by people who live nearby. Pursuant to legal, political and cultural circumstances in which the municipal forestry is carried out, it seems very considerate, and therefore this term may include a range of different experiences and practices.

10.1. Government institutions

Without government support, in terms of law enforcement and cooperation among different government departments, it is likely that the conservation of forest genetic resources will not be sustainable. It has to be kept in mind that the government plays important role when it comes to the outcome of the participatory process in conservation activities. It can provide environment suitable for participatory forest conservation in particular by:

• Decentralization of political, fiscal and administrative powers.

• Regulations on the security of land tenure and property rights.

• Education and other forms of capacity building.

Given the fact that the activities of conservation and sustainable use of forest genetic resources present integral part of forest management, critical participants in these activities are the Ministry of Agriculture, Forestry and Water Management, PFE "Šume Srpske", as well as private owners. On the other hand, the processes of evaluation, determination of the protection and conservation declaring areas of research, are to be carried by Faculty of Forestry and Genetic Resources Institute, acting as the organizational unit of the University of Banja Luka. The leading role in the implementation of the proposed activities of this program belongs to these two institutions, which are obliged to prepare the annual report to the Government of the Republic of Srpska through the relevant ministry department.

The implementation of the program involves strengthening inter-sector cooperation in the field of conservation and utilization of forest genetic resources, particularly among the Ministry of Agriculture, Forestry and Water Management, the Ministry of Science and Technology and the Ministry of Physical Planning, Civil Engineering and Ecology, and administrative organizations in Republic of Srpska, as well as significant public support to realize objectives and measures. Achieving the goals set in the program will require the effective use of currently available financial resources, and organizational and technical instruments, and all other instruments that will be developed during its implementation, which include instruments of legal, organizational, economic, research, technical, technological or educational nature.

The activities planned within this Program do not have time limitations and should be regarded as integral part of environmental policy, and the way to improve the current condition of forests and forestry in Republic of Srpska. Some of the envisaged activities have the character of one-off activities that will be implemented in the upcoming years when applicable.

There are two major challenges which departments of Forestry and Ecology need to face:

• Ensure that staff is well trained and informed about the technical aspects of conservation, management and utilization of forest genetic resources. Furthermore, since the participation in forestry and the conservation process is desired, it is necessary to obtain information on participatory approaches and ways of their implementation.

• Try to avoid bureaucratic obstacles that hinder problem solving and communication, not just among the staff and the local community, but also among staff at different levels in the hierarchy.

The staff employed in the department of forestry is to be encouraged to participate in workshops and courses related to participatory methods, and then to use these skills and make changes. Department of forestry, a major stakeholder in the forests preservation, needs to have qualified staff to constantly monitor the outcome of participatory conservation of forest genetic resources. Training should not exclude other stakeholders.

10.2. Local communities and NGOs

One of the basic requirements for successful implementation of the program is the active participation and mutual cooperation of all stakeholders in decision-making process and natural resource management: competent authorities and institutions at national and municipal level. and at the community level, also. Successful implementation of the planned measures is directly correlated with the level of joint and synchronized actions of participants in the implementation process: research institutions, educational institutions - universities, professional and business associations. An important role in the implementation of the Program is also held by civilian organizations in general, which monitor and control government's actions, and actively participate in the decision-making process.

Local participation is important in almost all conservation programs, but there are situations where it is absolutely necessary, for example, in areas that are characterized as areas with high population pressure and conflicts due to the resource utilization; within the areas which are in municipal property, and in less protected areas that are exposed to human activities. In these cases, the lack of local participation in conservation will lead to failure. Involving in the participation process and creating the appropriate legal and administrative environment are vital and complementary aspects of the conservation of forest genetic resources.

In most cases it was observed that non-governmental organizations play an important role as intermediaries between the government and other stakeholders in the forest conservation process. Non-governmental organizations are very different in terms of ideology, political and economic power and capacity of the organization. Just like the local community and the state in which they operate, NGOs are not a homogenous group and their interests may differ. Therefore it is not possible to fully assess the role of non-governmental organizations, however, it is a fact that NGOs often play a key role in the successful negotiation and joint management between people and the government. The presence of capable non-governmental groups that are interested in the environment, shows that there are changes in many countries in response to the growing competition for natural resources.

10.3. Users and interests

The benefit, which comes from the application of certain genetic material in forestry is in contact with many segments in society. It happens that genetic resources, which are of universal significance, are owned or used by individuals, communities and public organizations. The initial organization of the conservation process is extremely complex since the interest in forest genetic resources is large and multifaceted.

Since the distribution of species and ecosystems does not respect national boundaries, local populations can be developed via utilization and the domestication outside the natural range of species. Conservation of genetic resources in one country may be useful for other countries where these species grow or will have the potential in the future. For this reason there is a need for international conservation networks, which cooperation can contribute to increased effectiveness of national programs. However, from a practical point of view it is first necessary to develop an approach at the national level, which will be the basis for the international cooperation.

Planning process needs to take into the account assigning the tasks among existing units and to identify the need for the introduction of new units or structures, if necessary.

Direct beneficiaries of the forest genetic resources conservation is the public, however, more immediate and direct beneficiaries are groups and individuals who exploit the forest. All: government, public companies, private companies, non-governmental organizations (NGOs) are the stakeholders who often have different interests:

• The government and the authorities - usually the Ministry of Environment and / or services dealing with agriculture and forestry - have a long term interest in the conservation of genetic resources and biological diversity, and to maintain vegetative cover in order to protect the environment.

• The interest of state-owned enterprises and private companies is of economic character and is reflected in the improvement of timber production, which is also in the national economic interest.

• Non-governmental organizations may have similar interests, but these goals are generally idealistic and focus on the intrinsic value.

• The interests of private forest owners may be economic or existential, whether it is about wood for fuel, timber, food, shelter, or the environment protection.

Specific structures present a segment of the genetic resources conservation. Specific requirements in terms of infrastructure and staff, depend on the species and quantity of genetic resources in mind. When we take into the account the structure of the organization, it is important to understand that the main activities in the process of genetic resource conservation lie: (1) between the research work and practical application, (2) in long-term national interest of the conservation process, and (3) in the more immediate economic interests and / or existential interests .

10.4. Conflicts and solutions

Conflicts and discussions among stakeholders sometimes grow into bigger conflicts. Nowadays there aren't any "limitations to the resource exploitation," and almost any change in land utilization or expansion of resource exploitation tends to cause conflicts - among nations, regions, provinces or individuals. Among the villages there may be rivalry over resources. Conservation process can cause anger in other villages if it promotes the interests of one village or one group of stakeholders.

Conflicts are integral part of the social dynamics. A conflict will occur if a conservation action has adverse effects on any specific group. The risk of conflict will be reduced if all stakeholders are involved in the process of conservation planning and decision making. Even the most precise planning won't prevent creating conflicts. In this case, the person in charge needs to decide whether the conflict can be easily solved and whether it is necessary to search a new location.

It is necessary to distinguish conflicts which can be solved only by intervention from the conflicts which can be settled among the parties concerned. In some situations, interested parties can settle conflicts without the government intervention, according to local tradition of conflict solving. The following guidelines to settle conflicts can be helpful:

• Planners should seriously consider all complaints. Carefully listen both sides' concerns and comprehend the misunderstanding. Determine where and when to solve the complaints.

• Planners should not attempt to settle the conflict on their own. Complaints should be discussed in the presence of all stakeholders. It is necessary to determine the cause. What are the main problems? What actions are necessary to settle the conflict?

• If there are a lot of problems and fundamental issues to cope with, the advantage should be given in terms of (a) the size (number of people, land, trees that are affected by the issue) and (b) the importance (impact of the problem which affected all involved parties).

• Encourage all parties to seek positive solutions in every conflicting situation. Think about ways to compensate affected parties.

• Review and modify options until everybody agrees to the solution.

It should be noted that these guidelines depend on the voluntary participation of all stakeholders. Cultural frameworks, including the willingness of people to acknowledge the conflict in public, will make these guidelines more or less acceptable in different parts of the world. If the mediation process invites only certain sides, and the real cause of the conflict remains beyond the control, the process will be counterproductive for it will seem useless to the people.

10.5. Awareness-raising and education on the importance of forest genetic resources

Currently there is a shortage of qualified staff in the field of plant genetic resources, as well as the trained staff in the field of forest seeds, nursery, plant breeding, taxonomy, systematics, biodiversity, etc. The importance of education and training in the development and continuous improvement of the maintenance and utilization of plant genetic resources needs to be widely recognized. At a time when financial support for many programs in forestry is in question, financing training activities is particularly difficult. The lack of well-trained staff is evident at all levels and poses a significant problem.

Unlike scientific approach and publication of information in scientific papers, spreading information in pursuit of raising public awareness on the conservation and sustainable utilization of plant genetic resources is incomplete and insufficient. This is the reason why general public is not sufficiently aware of the current importance of these topics. Entity policy needs to recognize the role which animated public awareness may play in conservation and utilization of genetic resources. Animating public awareness as an important part, should be included in the design of all activities in this area at the state level.

Programs of conservation and sustainable utilization of genetic resources should have qualified people to raise people's awareness, which will actively deal with such issues. Moreover, people engaged in different areas of genetic resources conservation should have the ability to harmonize their program goals and activities in a wider context, which in the end should result in sustainable forestry development. They should establish a promotional relationship with all stakeholders in this field, using elaborate methods defined by experts to animate the public awareness.

11. PROGRAM IMPLEMENTATION (OBJECTIVES, MEASURES AND ORGANIZATION)

11.1. General objectives of the Program of forest genetic resources conservation

Main goal: To create a system for the conservation and sustainable utilization of forest genetic resources, implying the biodiversity preservation. Partial measures:

• Establish the genetic resource conservation as an activity of special interest and have it subjected to legislative measures.

• Establish conditions necessary for the development and the implementation of various conservation strategies, as well as for other actions necessary for the conservation and the sustainable utilization of genetic resources, i.e. achieve a balanced relationship between *in situ* and *ex situ* conservation.

• Create a database of all the activities carried out in the conservation and utilization of forest genetic resources accompanied with all key details. Create an information system of genetic resources, which would fully support efforts in conservation and sustainable utilization which are of interest for Republic of Srpska.

• Make the activities financed from budget resources available to all citizens in Republic of Srpska.

• Provide support to the seedling-nursery production in forestry which will follow the activities of forest genetic resources conservation.

• Assess (develop the scenario) the impact of climate change on forest genetic resources, as well as define the importance of preserving genetic resources in terms of adaptation of forest ecosystems to anticipated climate change.

11.2. The objectives of the *in situ* conservation in managed forests

Main goal: Create and manage a network in the line with the Pan-European minimal requirements for genetic conservation of forest trees (www.eufgis.eu). Partial measures:

• Define provenance regions in order to provide categories of reproductive material "of known origin" (according to the Law on Forest Reproductive Material).

• Survey and inventory of plant genetic resources at the level of ecosystems and species, review the existing collection and assess the genetic diversity.

• Set priorities by identifying the priority genetic resources, often at the species level.

• Determine the general genetic structure of the priority species, and assess the current protection level of certain species and their populations.

• Identify conservation priorities for individual species at the population level, and when it comes to a group of species at population level identify the geographic distribution of the population and the number of population included in the preservation (conservation) program.

• The choice of conservation and exploitation strategy and identify preservation measures - the biological and economic options.

• Organize and plan specific conservation activities.

• Management plans (forestry management units) should include the overview of the current condition, actions and suggestions towards the conservation of forest genetic resources, respecting the following sequence of events:

- Harmonize logging activities with the conservation of forest genetic resources.
- Define procedures when selecting trees to be harvested.
- Select the best methods to restore forests, and establish new forests.
- Management of non-timber (other) forest products.
- Define the area for the conservation of forest genetic resources in the forest management unit (FMU).
- Define the size of each conservation area within the FMU.
- Select the individual populations and habitats within the FMU.
- Develop a management plan for each conservation area.

11.3. The objectives of the in situ conservation in protected areas

Main goal: To improve the situation of endangered populations of forest trees and shrubs in protected areas through active protective measures. Partial measures:

• Collect and compare data on tree species found in the protected area.

• Undertake a detailed botanical inventory.

• Identify forest (especially woody species) genetic resources of high priority.

• For each forest genetic resources / species of high priority determine whether there is a need for special protection measures and management.

• Define the geographic distribution of endangered and rare species.

• Develop a general management plan and a plan for individual species.

• Conduct research work with a focus on the selected species.

• Provide information to interpretation and review the outcome of different management practices, as well as to provide guidelines for making decisions in future management practice.

• Consider each part of the plan / management plan, using information obtained through monitoring and other activities, and if necessary, develop new approaches and practices.

11.4. The objectives of the ex situ conservation

Main goal: To provide (establish) budget and sustainable use of forest gene banks of trees and shrubs, which will mainly rely on the seed bank, seed orchards and clone archives - according to significance, biological traits and threats. Partial measures:

• Define the sampling strategy in the *ex situ* conservation, as well as to define the hierarchical level of protection, conservation objectives, the size and number of samples, etc.

• Intensify the activities regarding the establishment of *ex situ* conservation plantations through the processes of their planning, establishment, maintenance, preservation and utilization.

• Establish the long-term *ex situ* diversity conservation of rare and endangered species and populations.

• Collect the species, ecotypes, varieties, or other cultivars, which are on the edge of extinction.

• Develop and optimize methods for the storage of seeds, pollen and in vitro conservation and cryopreservation.

• The conservation of the DNA archive should be accompanied by research on diversity via molecular markers.

• Establish a gene bank for forest trees and shrubs.

• Establish and improve plant protection methods, including quarantine regulations in the *ex situ* conservation.

11.5. Activities at the international level

Main goal: International promotion of national activities, the exchange of experience and establishment of joint international projects. Partial measures:

• Use and promote relationships to increase cooperation at the national and international level.

• Involvement in the EUFORGEN, appoint a national coordinator and pay a membership (plan budget provided by the Government).

• Establish links with related institutions and gene banks in the region and in Europe in order to exchange information and / or genetic material.

• Participate in regional projects and create joint collection plantations, cooperation in describing certain species.

• Promote access and exchange of information on genetic resources in accordance with relevant international agreements, including the CBD.

• Greater integration of local information systems in the European and international networks.

• Monitor the effects of climate change on the use and transfer of forest reproductive material.

• Comparative analysis of various European provenance regions for certain tree species.

• Define guidelines for the use of reproductive material at different altitudinal belts.

• Exchange of experience and defining technical guidelines for genetic species conservation.

• Preserve the quality of forest seed in processing and storage activities according to international standards, and develop the standards for forest planting material in conformity with international standards.

11.6. Transparency and raising the awareness in Republic of Srpska

Main goal: Complete transparency and the consensus of all the stakeholders' opinion. Partial measures:

• Public promotion of the program of forest genetic resources conservation.

• Establish transparency regarding the allocated responsibilities and authorities borne by state and local institutions, as well as duties among individuals, organizations and institutions involved in the conservation and utilization of forest genetic resources.

• Raising public awareness about the importance of forest genetic resources conservation by improving the education system at all levels, training; support to research work; visits to other institutions.

• Create a database of potential partners in the conservation process of forest genetic resources (scientific and technical institutions, forest management companies and contractors engaged in forestry activities, consultative services, private institutions, museums, educational institutions, non-governmental organizations, associations, etc.).

• Implement socio-economic and socio-cultural research work to understand the importance of forest genetic resources and our attitude towards them.

• Organize and register all active associations interested in forest genetic resources.

• Establish mechanisms for coordination and successful implementation of activities intended to raise public awareness at all levels.

• Improve public relations aimed at better understanding of the conservation and utilization of plant genetic resources at all levels (national, municipal, associations and interested individuals) through various types of promotional activities: discussions, public events, promoting the importance of national parks, botanical gardens, visits to demonstration facilities etc..

•Publication of useful information on conservation of forest genetic resources.

11.7. Train the staff engaged in the Program implementation

Main goal: Raise awareness of the importance of forest genetic resources. Partial measures:

• Provide necessary education and training for all activities related to the conservation and sustainable conservation of forest genetic resources, and the management and policy management, as well.

• Build local capacity in order to provide necessary education and training in field of the conservation of forest genetic resources and to establish effective cooperation of relevant institutions with similar institutions in developed countries.

• Develop appropriate short courses and training modules for areas identified as priorities.

• Facilitate the education and training efforts of local staff in developed countries.

• Support research institutions and institutions regarding the idea of including the issue of conserving forest genetic resources in the appropriate courses and programs of biological and biotechnical sciences.

• The care for plant genetic resources implies offering courses at the highest level of education in the field of forestry.

• Create the conditions to prepare and print materials which will form an integral part in education.

11.8. Research work

• Make a list of research work, developmental programs and models of projects, which are currently funded, and publish the list within the information system of genetic resources.

• Improve and create new programs to fund research, developmental programs and models of projects for biodiversity, giving special importance to forest genetic resources.

• Include the use of molecular techniques for marking activities.

• Study the reaction of various species to ex situ conservation methods.

• The study of intraspecific variability via different tools and methods.

• Provide scientific and technical basis for the development, including significant amount of financing resources for research work.

• Permanent specialization courses in the country and abroad.

• Intensive efforts to provide international support in the research of genetic resources in our country.

• Through the research work to contribute to the decision making process, especially when it comes to the following questions:

 Where are the remaining trees located - the populations of selected species and what is their conservation status?

 What populations (locations) should be protected (or they provide the basis for the seed collection which will be subjected to *ex situ* conservation process)?

 How big should the conservation unit be?

 How to manage the areas under conservation?

 What are the reproduction forms of trees in *ex situ* conservation?

 What types of utilization is in use, and how to combine utilization and conservation processes?

11.9. Organization

• Establish the Committee on Forest Genetic Resources (Committee members are appointed by the Minister of Agriculture, Forestry and Water Management of the Republic of Srpska for a period of 5 years). The Committee assignments: consultative role in proposing legislation in the field of conservation of forest genetic resources, monitoring the implementation of the program, develop the Action Plan to implement measures defined by the Program. The Committee will be appointed by the Minister within three months after the Program is adopted.

• Develop the Action Plan within 6 months after the Committee is appointed, which will provide a three-year period of action measures (Committee members work out the action plan).

• Faculty of Forestry and Genetic Resources Institute, University of Banja Luka, are in charge of the Program implementation. Specific responsibilities will be defined in the action plan.

• Strengthening the institutional and human resources employed within the institutions in charge of the program implementation.

• Coordinate activities among all participants of Plant conservation program and the Program of forest genetic resources conservation in Republic of Srpska.

• Involve members of the Committee on Forest Genetic Resources in the ongoing activities of the Committee for Plant Genetic Resources, and other way round.

•Propose rules and regulations:

for the management, preservation and the access to forest genetic resources,

for the protection of traditional knowledge,

to distribute the income obtained by the genetic resource utilization,

to define appropriate financial incentives and incentives for forest owners (e.g., owners exempted from property tax when registering areas for genetic conservation)

• Faculty of Forestry and Genetic Resources Institute, University of Banja Luka, will submit the annual report on the Program implementation to the Republic of Srpska Government, and every three years through the Ministry department to the National Assembly of Republic of Srpska.

• Ministry of Agriculture, Forestry and Water Management with its budget provides partial financial support to the Program till 2014. The budget framework within 2013 - 2017 allocates resources to the project: 2013 - 100.000KM (to create the Action Plan); 2014 – 100.000KM (to propose rules and regulations) and 2015 - 200,000 KM (laboratory equipment, field sampling, analysis of the initial results on the genetic diversity using molecular markers- of the most interesting species in Republic of Srpska); 2016-2017 -200.000KM (specific suggestions to preserve certain populations and publishing first solid results obtained in the activities of forest genetic resources conservation). In addition to these resources, there are options to co-finance the program from the allocated resources for scientific and technological development of Republic of Srpska, and other resources coming from international funds intended for the preservation of biological diversity. Faculty of Forestry / the Institute of Genetic Resources will submit the annual report on the Program implementation to the Republic of Srpska Government.

12. PROGRAM WAS DEVELOPED AND IMPLEMENTED BY FOLLOWING PARTICIPANTS

Forestry Agency

Society for the Protection of trees - Arbor MAGNA, et al.

Industrial plantations

Genetic Resources Institute, University of Banja Luka

PFE "Šume Republike Srpske" a.d. Sokolac with all organizational units

Local communities

Ministry for Foreign Economic Relations and Coordination

Ministry of Physical Planning, Civil Engineering and Ecology

Ministry of Science and Technology

Ministry of Agriculture, Forestry and Water Management

Ministry of Education and Culture

Ministry of Trade and Tourism

Ministry of Local Administration

Ministry of Finance

Agricultural Institute of the Republic of Srpska, Banja Luka

Faculty of Agriculture, University of Banja Luka

Faculty of Science, University of Banja Luka

Republic Institute for Protection of Monuments and Cultural Heritage

Secondary Forestry Schools

Association of Forestry Engineers and technicans in Republic of Srpska

Hydrometeorological Service in Republic of Srpska

Faculty of Forestry, University of Banja Luka

13. INTERNATIONAL ORGANIZATIONS AND INSTITUTIONS ENGAGED IN THE CONSERVATION OF FOREST GENETIC RESOURCES

-ATSC - The Australian Tree Seed Centre (ATSC) is a seed center under the Forestry and Forest Products Division of the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO).

-Bioversity International - Bioversity International, an international organization, developing research on conservation and use of agricultural biodiversity.

-CAMCORE - Central America and Mexico Coniferous Resources Cooperative based at North Carolina State University. The objective of the cooperative is "to conserve, test, and improve forest species in the tropics and subtropics for the benefit of humankind."

-CATIE - Centro Agronomic Tropical de Investigación y Enseñanza, Turrialba, Costa Rica.

-CBD - The Convention on Biological Diversity, including the Cartagena Protocol on Biosafety, which aims to ensure the safe handling, transport and use of living modified organisms (LMOs) resulting from modern biotechnology that may have adverse effects on biological diversity.

-CIFOR - Center for International Forestry Research, based in Jakarta, Indonesia.

-CIFOR - Center for International Forestry Research, www.cifor.cgiar.org

-DFSC - The Danida Forest Seed Centre (DFSC) is a seed center financed by the Danish International Development Aid (Danida). The center is located in Denmark, but activitites are directed towards developing countries with special focus on procurement and handling of tree seed, conservation of forest genetic resources and tree improvement.

EC-(European Commission). Its activities are focused on the sustainable use and conservation of genetic resources covering:

- The EU Operational Programme South East Europe the possibility of financing cooperation in various fields (including forestry) among all the countries of South Eastern Europe.
- DG SANCO - Directorate General Health and Consumers Protection - Standing Committee of reproductive material in agriculture, horticulture and forestry.
- AGRI GENRES - EU program for the identification, characterization and conservation of genetic resources in agriculture

- EUFGIS - Pan-European information system on forest genetic resources - linking national inventory of forest genetic resources in Europe. http://www.eufgis.org/

-EUFORGEN - The European Forest Genetic Resources Programme

FAO - United Nations Organization for Food and Agriculture, www.fao.org

- Forest Europe - Ministerial Conferences on Protection of Forests in Europe www.mcpfe.org

-FGC - The Forest Genetics Council of British Columbia

-GEF - Global Environment Facility, www.gefweb.org

-GENRES - The Information System on Genetic Resources (GENRES) is maintained by the Information Centre for Genetic Resources at the German Centre for Documentation and Information in Agriculture, under the auspices of the German Federal Ministry of Food, Agriculture and Forestry.

-INRA – The Laboratory of Forest Genetics and Tree Improvement of INRA Cestas (Institut National de la Recherche Agronomique) is conducting activities in population and quantitative genetics of temperate and tropical tree species.

IPC-The International Poplar Commission (IPC) is one of the Statutory Bodies of FAO. Notwithstanding its name, the mandate of the Commission covers willows as well as poplars.

-IPGRI - International Institute for Plant Genetic Resources, www.ipgri.cgiar.org

- IPGRI The International Plant Genetic Research Institute, based in Rome, Italy. Now Bioversity International.

-IPNI - The International Plant Names Index (IPNI) is a database of the names and associated basic bibliographical details of all seed plants, it is the product of a collaboration between The Royal Botanic Gardens, Kew, The Harvard University Herbaria and the Australian National Herbarium .

-IUCN - The International Union for Conservation of Nature, www.iucn.org

-IUFRO – The International Union of Forestry Research Organizations, based in Vienna, Austria. www.iufro.boku.ac.at.

-METLA - The Finnish Forest Research Institute's page on forest genetics and tree breeding.

-OECD - The Organisation for Economic Co-operation and Development. The OECD activities related to forest genetic resources include:

- OECD Scheme for Certification of Forest Reproductive Materials Moving in International Trade
- BioTrack / Biosafety (with records of field trials of genetically modified trees and Consensus Documents on the Biology of tree species).

-UNDP - United Nations Development Programme, www.undp.org

-UNEP - United Nations Environment Programme, www.unep.org

-UNESCO - United Nations Educational, Scientific and Cultural Organization, www.unesco.org

-WB - World Bank, www.worldbank.org

14. ABBREVIATIONS

BI - Bioversity International

CBD - Convention of Biological Diversity

CGIAR - The Conslutative Group on International Agriculture Research

CITES - Convention on International Trade in Endangered Species of Wild Flora and Fauna

ECPGR - European Cooperative Programme for Plant Genetic Resources

EPPO - European and Mediterranean Plant Protection Organization

EUFGIS - European Forest Genetic Information System

EUFORGEN - European Forest Genetic Resources Programme

FAO - World Organization for Food and Agriculture

FGR - Forest Genetic Resources

FMU - Forest Management Unit

HCVF-High conservation value forest-forests of high conservation value

IBPGR - International Board for Plant Genetic Resources

IPGRI - International Plant Genetic Resources Institute

IPPC - International Plant Protection Convention

ISTA - International Seed Testing Association

ITPGR - International Treaty on Plant Genetic Resources

ITPGRFA - The International Treaty on Plant Genetic Resources for Food and Agriculture

IUCN - The World Conservation Union

MTAs - Material Transfer Agreements

NEAP - National Environmental Action Plan

NWFP - Non-wood forest products

OECD - Organization for Economic Cooperation and Development Coopeation

RAMSAR - The Convention on Wetlans

SEEDNet - South East European Development Network

SFM - Sustainable Forest Management

AIDS - Swedish International Development Cooperation Agency

TRIPS – Trade - related aspects of Intellectual Property Rights

UNCED - UN Conference on Environment and Development - the "Earth Summit")

UNCHE - UN Conference on Human Environment

UNEP - United Nations Environment Programme

UPOV - International Union for the Protection of New Varieties of Plants

WIPO - World Intellectual Property Organization

WSSD - World Summit on Sustainable Development

WTO - World Trade Organization

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16. ATTACHMENTS

Annex 1

HCVF in the Republic of Srpska

Forest Management Unit	Seed stands					Protected endangered species	Protected areas	Protected stream s	Erosion Plots.	Fire protected	Tradition	Total [ha]	Total area [ha]	HCVF [%]
	Fir / Spruce	Pine	Beech	Sessile Oak	Serbian. spruce									
1.Banjaluka			112.5	36.1				1411.97	341.64		1838.46	3740.67	48339	7.74
2.Drinić	22.80	15.60					2345.70					2384.10	20385	11.70
3.Panos	44.20	166.20			55.3			844.90				1110.60	43527	2.55
4.Birač	32.50	3.00	20.00		4.90			459.75	2671.00		34.60	325.75	40890	7.89
5.Gradiška			37.65	17.0		0.50		300.00	961.56		338.67	1655.38	39884	4.15
6.Doboj								579.96		5.40	33.80	619.16	34510	1.79
7.Zelengora	5.69						1909.76	2686.83	417.05			5019.33	35024	14.33
8.Čemernica	115.42					822.27		709.88				1647.57	14969	11.01
9.Vrbanja								229.37	512.47		603.36	1345.20	23730	5.67
10.Majevica								933.40				933.40	7505	12.44
11.Lisina								259.46	995.20			1254.66	30000	4.18
12.Botin							10.00	10.00				20.00	60143	0.03
13.Jahorina	35.80							370.50			38.00	444.30	31314	1.42
14.Prijedor			22.80	21.7		9.00	15.00	96.20	2.00		64.50	231.20	42442	0.54
15.Ribnik	8.90					101.05		1675.90				1785.85	32099	5.56
16.Sjemić								4066.60	359.90			4426.50	40091	11.04
17.Romanija	17.30	14.30						1642.90	73.15		875.81	2623.46	44916	5.84
18.Drina	20.00				3.00			367.94	1868.76			2259.70	37792	5.98
19.Maglić	24.00	9.00						3639.50			99.20	3771.70	55401	6.81
20.Borja		2.20		3.97		8.41		5.00			220.94	240.52	48183	0.50
21.Visočnik	146.19					10.00		14.17	169.48		1188.90	1528.74	20719	7.38
22.Vučevica									193.50		63.90	257.40	18993	1.36
23.Gorica						391.57	1832.84	737.91	598.76		116.40	3677.48	37449	9.82
24.Cen.krš													174398	0.00
Total	**472.80**	210.30	192.95	78.77	63.2	1342.8	6113.30	21042.14	9164.47	5.40	5516.54	44202.67	982703	4.50
	Vzv-1a				HCVF -1c	HCVF -1b	HCVF -1	HCVF -4a	HCVF -4b	HCVF -4c	HCVF -6			

Appendix 2

The proposed network of protected nature areas in Republic of Srpska

IUCN Category I - Strict Nature Reserve and wilderness areas

a) Virgin forest: Lom, Janj, Perućica

b) Areas of special natural value (proposal)

- Klekovača-Lom
- Vitoroga (part of), Ugar river Vrbas (Vrbas Canyon, Crna River and Ugar)
- Bardača

c) Conserved protected ecosystems of larger areas (proposal)

- Canyon of Miljacka River with the surroundings

IUCN Category II - National Parks

- National park "Kozara" (existing)
- National Park "Sutjeska '(existing)
- Maglić and Zelengora expanding on Volujak and Lebršnik (proposal)
- The Tara River Canyon - part (proposal)
- Jahorina and the Prača River spring (proposal)
- Treskavica and the Bistrica River Canyon (proposal)
- The Drina River Canyon and Sučica (proposal)

(**IUCN category III**) Monuments of Nature

a) Geomorphological monuments: Earth Pyramids close to Miljevina, "Written rocks" in Žlijeb, a slap on the Bistrica river.

b) speleological monuments

Caves: Cave Vagan, Soko cave, Čukovac, Subotića cave, cave in Central Jurkovica, caves underneath the old city Đurđevac, Great cave, cave Lednice, cave Banja stojena, cave Govještica, cave Propastva, cave Glavičine, cave Zobnjak, cave Rakovac, cave Čeljina, cave close to river Vrhovine, cave Vranjača, cave Novakuša, cave Provalija, cave Rušpija, cave Snjetnica, cave Visibaba, cave Ljelješnica, caves Ponikva, Great cave, Vilina cave, Cave od Dolama, cave Vjetrenica, cave on "Ilino brdo".

Jame: Grkova pit, pit Pandurica, pit to Rye.

c) Hydrological monuments of nature

Wells and springs: Sana spring, Čenića spring, Pliva river srping, Janja river spring, Krupa river spring, Velika voda spring, Paljanska Miljacka spring, Gornji Krupac spring, Donji Krupac spring, Pridvorice spring, karst spring Šumet.

Hot Springs: Hot Springs Srpske toplice (Šeher), Laktaši Spa with its surroundings, Kulaši Spa with the landscape, Vrućica Spa with the landscape, Crni Guber, Spring Bioštica.

Watercourses: Gomjenica, Kremnica, Željeznica (part of the flow), Trebišnjica (part of the flow).

Falls: Falls on Janja river close to Bukva, waterfall at Janja river – Sokolina, waterfall along the road to Sokolina.

Cliffs: Janja, Sokolina, Ilomska river, Prača, Sijračke stijene.

Travertine formations: travertine in Studena Canyon, travertine in Crkvena area, travertine at Pale with a waterfall, travertine in Jasenova, travertine in Sitnica stream.

Lakes: Dragnić, Olićko Lake, White Lake, Big Lake, Platno Lake, Trokunsko Lake, Black Lake, a lake Rječica, a lake in the Gornje Bare, a lake in Donje bare, Uloško lake, Lake Štirinsko Lake Katlaničko lake.

Sinks: sink Široko vrelo, sink Pejov do, sink behaind Pejova Do, sink river Zalomka, sink Zvonuša, sink Obod.

Other: Djevići vir, Kazani on Željeznica river

d) Botanical monuments of nature: Patterns of forest phytocenoses and groups of trees, the largest tree specimens, other botanical monuments of nature.

e) Natural rarity: rare plant species (ferns site of Gospina vlas, birch), rare ecosystems (peat bog with birch).

(IUCN category IV) - areas with management of habitats

Degraded protected ecosystems (in preparation).

(IUCN category V) - PROTECTED LANDSCAPES

a) Nature reserves (Regional Parks): Pliva river with Sokočnica, Janja river, upper part of Sana river, Zvornik lake-Drinjača-Jadar, Jahorina, Trebevic, Viogor-Lim, Valley Ćehotina.

b) Forest Park: Zelenkovac, Rogolji nursery, Omar, Šikare and Opsečko, recreation areas in Kotor Varoš, forest – resort (picnic) near Prnjavor, Recreation Complex near Doboj, Jakeš, Zborište, Forest Park, near Bijeljina Studenkovići, Forest Park Zlatište, Bulozi, Forest Park Pale, Forest Park Gnjilo brdo, forests around Višegrad spa, Stržišta and Zrtar-city, Cicelj, Trebinjska forest.

c) Significant Landscapes: Lake Balkana with the landscape, Karst springs Kozica and valley Vučaj-stream, Krupa na Vrbasu, Canyon Cvrcka, Canyong Ilomska River, upper part of the Usora river and its tributaries, Vučjak Lake and its surrounding, Klinje lake, Borilovačko lake, Bilećko Lake.

d) Protection forests: “Rokin do”, part of the Pliva and Janja river watershed, Starčevica Bjeljevine, Strmac-Vilusi, water protection zone of Veselinovac and Risovac watercourses, Vlasenica spring protection forest, coppice beech forest in the Drina river canyon unsuitable for management, of Kasindolska River Canyon, Piskuša, Tilava spring, protective buffer of ski slopes and resorts in Jahorina, Canyon of “Sijeracke stijene”, Areas around the power plants and reservoirs, Lim Rudo.

e) The natural areas around the cultural heritage resource management (in preparation)

(IUCN Category VI) - PROTECTED AREAS FOR RESOURCE MANAGEMENT

a) The gene pool reserves: flora genetic reserves (seed stands of indigenous species), the group of rare tree species, live natural collections, fauna gene pool reserves (great grouse habitat).

b) Monuments of landscape architecture: Tree lines in Prijedor, Old alleys in Banja Luka, “Petar Kočić” Park - Banja Luka, “Mladen Stojanović” Park Banja Luka, Recreation park “Ada” Banja Luka, Old Park in Podgradci, Memorial park Vukosavci , City Park in Bijeljina, Old alleys in Bijeljina, Trebinje alley of platan treees.

Source of data: Project network of protected nature areas (Phase Report for 2005.).
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Authors: PhD Vojin Buca, MSc Jugoslav Brujić and Jovo Travar, BSc.

Appendix 3
The overview of valuable, rare and endangered forest ecosystems in Republic of Srpska - important genetic resources - by priority level

All species and ecosystems are divided into three groups:
α) species (ecosystems) for which no measure would help conservation
β) species (ecosystems) which will survive without management activities
γ) species (ecosystems) which will survive if they are suitably managed (as far as resources allow).

Ecosystem	Group priorities
Q U E R C O - F A G E T E A Br.-Bl. et Vlieger 1937	
Quercetea ilicis Br.-Bl. 1947	
Quercetalia ilicis Br.-Bl. (1931) 1936	
Oleo-Ceratonion Br.-Bl. 1936	
Seslerio-Juniperetum phoeniceae Lak., D. Pavl. et Redžić 1982	α
Quercion ilicis Br.-Bl. (1931) 1936	
Orno-Quercetum ilicis H-ić 1958	α
Paliuretea Trinajstić 1978	
Paliuretalia Trinajstić 1978	
Paliurion adriaticum Trinajstić 1978	
Petterietum ramentaceae Fuk. 1968	α
Spartietum juncei Lak. et al. 1982	γ
Euphorbio-Paliuretum spinae-christi Bog. 1969	β
Quercetalia pubescentis Br.-Bl. (1931) 1932	
Ostryo-Carpinion orientalis Ht. 1954, emend. 1958	
Querco-Carpinetum orientalis croaticum H-ić 1939	β
Rusco-Carpinetum orientalis Bleč. et Lak. 1966	α
Orno-Carpinetum orientalis Fab., Fuk. et Stef. 1963	β
Phillyreo-Carpinetum orientalis Em 1957	β
Quercetum trojanae montenegrinum Bleč. et Lak. 1975	α
Ostryo-Quercetum pubescentis Trin. 1974	α
Seslerio-Ostryetum Ht. et H-ić 1950	β
Seslerio autumnalis-Quercetum pubescentis Puncer et Zup. 1985	α
Quercion pubescentis-petraeae Br.-Bl. 1931	
Lathyro-Quercetum petraeae Ht. (1938) 1958	β
Quercion frainetto Ht. 1954	
Quercetum frainetto-cerridis Rudski (1940) 1949	β
Carpino betuli-Quercetum frainetto-cerridis (Rudski 1940) Jov. 1979	α
Juglando-Quercetum frainetto-cerridis Vuk.E. (1974) 1979	γ
Quercetum frainetto herzegovinicum Fukarek (1961) 1963	α
Quercion petraeae-cerridis Lakušić et Jovanović B. (1976) 1980	
Orno-Quercetum cerridis Stefanović 1968	β
Quercetum cerridis mediteraneo-montanum Lakušić et Kutleša Q. 1976	α
Quercetum montanum Černjavski et Jovanović B. (1948) 1953	β
Quercetum montanum serpentinicum Jovanović B. 1959	β
Orno-Quercetum petraeae Em 1968	β
Aceri tatarici-Quercion Zolyomi et Jakucs 1957	

Helleboro multifidi-Quercetum roboris V.Stupar prov.*	γ
Cotino-Cotoneastrion Fukarek (1958) 1979	
Cotinetum coggygriae calcicolum Fukarek (1958) 1968	β
Cotinetum coggygriae serpentinicum H.R.-St. 1972	β
Amelanchiero-Cotoneastretum Fukarek 1970	β
Rhuetum coriariae Tomašević 1959	γ
POPULETALIA ALBAE Br.-Bl. 1931	
Alnion incanae Pawl. 1928	
Circaeo-Alnetum Fukarek 1969	γ
Salicion albae Soò (1930) 1940	
Salicetum albae-fragilis Soò 1958	α
Salici-Populetum (R.Tx. 1931) M.Drees 1936	α
Alno-Quercion roboris Ht. (1937) 1938	
Genisto elatae-Quercetum roboris Ht. 1962	γ
Quercetum roboris montanum Stef. (1960) 1969	γ
FAGETALIA SILVATICAE Pawl. 1928	
Carpinion betuli illyrico-moesiacum Ht. 1956	
Querco - Carpinetum betuli (Ht. 1938) Wraber 1960	α
Querco-Carpinetum montenegrinum Blecic 1958	β
Carpino betuli-Quercetum roboris Anić 1959, apud Rauš 1969	γ
Carpinetum betuli Dinic 1977	β
Epimedio-Carpinetum betuli *	α
Fraxino-Acerion Fuk. 1969	
Ulmo-Aceretum illyricum Fukarek 1960	α
Aceri-Fraxinetum (croaticum) Ht. 1938	α
Salvio-Juglandetum Brujić 2003*	γ
Petasiti-Abietetum Brujic 2003*	β
Ostryo-Fagenion moesiacae Jov. 1976	
Seslerio autumnalis-Fagetum moesiacae Blečić & Lakušić 1970	β
Fagion illyricum Ht. (1938) 1950	
Primulo-Fagenion Borhidi 1963	
Melico-Fagetum Fabijanić, Fukarek et Stefanović 1963	α
Lathyro-Fagetum (Ht. 1938) Fabijanić 1963	γ
Rusco hypoglossi - Fagetum (subpannonicum) Stef. 1990	γ
Abieti-Fagetum (praepannonicum) Fab. 1963	α
Aceri-Fraxini-Carpini-Fagetum (mixtum) Misic 1963	β
Lonicero-Fagenion Borhidi 1963	
Abieti-Fagetum dinaricum (Ht. 1938) Tregubov 1957, emend. Puncer 1978	α
Fagetum montanum illyricum Fukarek et Stefanović 1958	β
Fago-Abietetum serpentinicum H.R.-St. 1970	β
Fagenion illyricum subalpinum Zup. 1985	
Fagetum subalpinum dinaricum (Ht. 1938) Treg. 1957	α
Aceri visianii-Fagetum Fukarek et Stefanović 1958	β
Ostryo-Fagenion illyricum Borhidi 1963	
Seslerio autumnalis-Fagetum (Ht. 1950; M.Wraber 1957) M.Wraber 1960	α
Aceri obtusati-Fagetum Fabijanić, Fukarek et Stefanović 1963	β
Aceri-Tilietum mixtum Stefanović 1979	β

Luzulo-Fagenion illyricum Mar. et Zup. 1979	
Blechno-Fagetum (Ht. 1950) Ht. 1962, emend. Marinček 1970	β
Castaneo-Fagetum Glićić (1954) 1975	γ
Fagion medioeuropaeum Soò (1960) 1962	
Luzulo-Fagenion Lohmayer et R.Tx. 1954	
Luzulo-Fagetum Mausel 1937	β
Polytricho formosi-Fagetum Jov.	α
QUERCETALIA ROBORI-PETRAEAE R.Tx. (1931) 1937	
Quercion robori-petraeae Br.-Bl. 1932	
Erico-Quercetum petraeae (Kraus et Ludwig 1957) Ht. 1959	β
Quercetum montanum illyricum Stefanović (1961) 1964	α
Calluno-Quercetum petraeae montanum serpentinicum H.R.-St. 1970	β
Castanetum sativae hercegovinicum M.Wraber (1958) 1961	γ
Salici capreae-Betuletum Stefanović 1969	β
Ilici-Fagion *	
Ilici-Fagetum prov.*	γ
PRUNETALIA SPINOSAE R.Tx. 1952	
Berberidion vulgaris Br.-Bl. 1950	
Corno-Ligustretum croaticum Ht. 1956	β
Crataego-Prunetum spinosae Beus 1971	β
Crataego-Corylion Fuk. 1969	
Coryletum avellanae Fuk. 1958	β
RHAMNETALIA FALLACIS Fuk. 1969	
Lonicero-Rhamnion Fuk. 1969	
Cynancho-Rhamnetum Fuk. et Stef. 1958	γ
Ribo-Loniceretum Fuk. 1969	β
Arctostaphyllo-Sorbetum Fuk. 1969	β
Cytisanthion radiati Randj. et Rexhepi 1979	
Daphno-Cytisanthetum radiati calcicolum Lak. et al. 1978	γ
Daphnetum oleoides Lak. 1968	β
Cytisanthi-Geranietum macrorrhizi Lak. et al. 1981	α
Cytisanthetum radiati Fuk.	α
VACCINIO-PICEETEA Br.-Bl. 1939, em. Zup. 1976	
VACCINIO-PICEETALIA Br.-Bl. 1939, emend. K.Lund. 1967	
Vaccinio-Piceion Br.-Bl. (1938) 1939	
Abieti-Piceenion Br.-Bl. 1939	
Fago-Abietetum Stefanović 1964	α
Blechno-Abietetum Ht. (1938,1955) 1959	α
Abieti-Piceetum illyricum Fuk. 1960, emend. Stef. 1962	β
Pyrolo-Piceetum Fuk. 1964	γ
Lycopodio-Piceetum montanum Stef. 1964	γ
Sphagno-Piceetum montanum Stef. 1964	γ
Sphagno-Abietetum Brujic et Stupar prov. *	γ
Querco-Piceo-Pinetum Stef. 1970	β
Piceo-Abieti-Fagetum (Treg. 1941) Čolić 1965. emend. Gajić et al. 1992	β
Eu-Vaccinio-Piceenion Oberd. 1957	
Aceri visianii-Piceetum subalpinum Stef. 1970	α

Sorbo-Piceetum Fuk. 1964	β
Piceion omorikae Treg. 1941	
Piceetum omorikae Treg. 1941	γ
Goodyero-Piceetum omorikae Fuk. 1969	γ
Daphno blagayanae-Piceetum omorikae Fuk. 1969	γ
Piceetum omorikae subalpinum Lak, Kutleša et Grgić 1980	γ
Calamagrostio-Abietion Ht. 1956	
Rhamno-Abietetum Fuk. 1958	γ
Pinion silvestris (Aichinger 1933) Lak. 1972	
Piceo-Pinetum illyricum Stef. 1959	β
Piceo-Pinetum silicicolum Stef. 1954	β
Leucobryo-Piceo-Pinetum Stef. (1960) 1961	γ
Erici-Piceo-Pinetum Bucalo 1999	β
Pinion mugo Pawl. 1928	
Pinetum mugo dinaricum silicicolum Lak. 1974	γ
Gentiano punctatae-Pinetum mugo Fuk. 1969	α
Pinetum mugo Lak. et al. 1979	α
Erico-Pinetum mugo Lak. et al. 1979	α
Juniperion sibiricae Br.-Bl. 1939	
Auilegio-Rhododendretum hirsuti Lak.et al. 1979	α
VACCINIETALIA Lak. et al. 1979	
Vaccinion uliginosi Lak. 1974	
Hyperico-Vaccinietum bosniacum Lak.et al. 1979	β
ERICO-PINETEA Ht. 1959	
ERICO-PINETALIA Oberd.1949 em Ht.1959	
Orno-Ostryon Tomažič 1940	
Erico-Ostryetum Ht. 1956	γ
Querco-Ostryetum Ht. 1938	α
Seslerio angustifoliae-Ostryetum Lak. 1975	β
Orno-Ericion Ht. 1958	
Orno-Ericenion dolomiticum Ht. 1957	
Genisto januensis-Pinetum Tomažič 1940	β
Helleboro-Pinetum Ht. 1958	β
Cotoneastro-Pinetum nigrae Ht. 1938	β
Cephalario flavae-Pinetum nigrae H.R.-St. 1967	β
Pinetum silvestris dinaricum Stef. 1958	β
Pinetum illyricum calcicolum Stef. 1960	α
Laserpitio sileri-Pinetum nigrae Fuk. 1969	β
Erico manipuliflorae-Pinetum H.R.-St. 1967	β
Daphno cneori-Pinetum H.R.St. ex Bucalo 1998	β
Orno-Ericenion serpentinicum Ht. 1957 apud Krause et Ludwig	
Erico-Pinetum silvestris serpentinicum Stef. 1963	α
Pinetum nigrae baziferens Stef. 1973	β
Cotino-Pinetum nigrae Fuk. 1969	β
Pinion heldreichii Ht. 1946	
Senecio visianii-Pinetum heldreichii Fuk. 1966	α
Pinetum mugo-heldreichii Fuk. 1966	γ

ALNETEA GLUTINOSAE Br.-Bl. et R.Tx.1943	
ALNETALIA GLUTINOSAE R.Tx. 1937	
Salicion cinereae Müller et Gors. 1958	
Pino-Betuletum pubescentis Stef. 1962	γ
Alnion glutinosae (Meijer & Malcuit 1929) Drees 1936	
Frangulo-Alnetum glutinosae Rauš 1969	β
Carici elongatae-Alnetum glutinosae W.Koch 1926	γ
Alnetum glutinosae montanum Fuk. 1969	γ
Leucoio-Fraxinetum angustifoliae Glavač 1959	γ
BETULO - ADENOSTYLETEA Br.-Bl.1948	
ADENOSTYLETALIA G.et J.Br.-Bl. 1931	
Adenostylion alliariae Br.-Bl. 1925	
Salicetum appendiculatae (Br.-Bl. 1950), Oberd. 1957 emend. Oberd. 1962	β
Alnion viridis Aich.1933	
Agrostio-Alnetum viridis Pavlović et Lakušić 1965	β
Athyrio-Alnetum viridis Stefanović et Beus 1975	β
EPILOBIETEA ANGUSTIFOLII R.Tx.et Preising 1950	
ATROPETALIA Vlieger 1937	
Chamaenerion angustifolii (Rübel) Soò 1933	
Inulo-Rubetum tomentosi Vukićević E. 1965	β
Calamagrostietum epigei Juraszek 1928	β
Atropion belladonnae Br.-Bl.em Oberd.1957	
Telekietum speciosae Treg. 1941	γ
Sambuco-Salicion capreae R.Tx.1950	
Sambucetum racemosae (Noirfolk 1949) Oberd. 1973	γ

The list includes all forest communities in Republic of Srpska, acording to sintaxonomy done by the Scientific Council of vegetation maps of Yugoslavia (Bribir-Ilok 1986), later supplemented with (*).

Appendix 4
The overview of valuable, rare and endangered species in Republic of Srpska - important genetic resources - by priority level

All species and ecosystems are divided into three groups:
α) species (ecosystems) for which no measures would help conservation
β) species (ecosystems) which will survive without management activities
γ) species (ecosystems) which will survive if they are suitably managed (as far as resources allow).

LICHEN	**Group**
Cladonia subgen. Cladina	α
Collema italicum B.de Lesd.	α
Lobaria amplissima (Scop.) Forss	γ
Parmeliella plumbea (Lightf.) Vaino	γ
Peltigera venosa (L.) Hoffm.	α
Pertusaria servitiana Erkichs	γ
Ramalina obtusata (Arnold) Bitter	α
Usnea longissima Ach	α

MOSS	**Group**
Sphagnum angustifolium (C.E.O. Jensen ex Russow) C.E.O. Jensen	γ
Sphagnum auriculatum Schimp.	γ
Sphagnum capillifolium (Ehrh.) Hedw.	γ
Sphagnum centrale C.E.O. Jensen	γ
Sphagnum cuspidatum Ehrh. ex. Hoffm.	γ
Sphagnum fallax (H. Klinggr.) H. Klinggr.	γ
Sphagnum fimbriatum Wilson	γ
Sphagnum flexuosum Dozy & Molk.	γ
Sphagnum girgensohnii Russow	γ
Sphagnum inundatum Russow	γ
Sphagnum palustre L.	γ
Sphagnum papillosum Lindb.	γ
Sphagnum platyphyllum (Lindb. ex Braithw.) Warnst.	γ
Sphagnum quinquefarium (Braithw.) Warnst.	γ
Sphagnum rubellum Wilson	γ
Sphagnum russowii Warnst.	γ
Sphagnum squarrosum Crome	γ
Sphagnum subsecundum Nees	γ
Entosthodon pulchellus (H. Philib.) Brugués	α
Physcomitrium sphaericum (C.F. Ludw. ex Schkuhr) Brid.	α
Brachydontium trichodes (F. Weber) Milde	α
Fissidens bryoides Hedw.	γ
Dicranum viride (Sull. & Lesq.) Lindb.	α
Leucobryum glaucum L.	β
Paraleucobryum sauteri (Bruch & Schimp.) Loeske	α
Tortula lingulata Lindb.	α
Tortula marginata (Bruch & Schimp.) Spruce	γ
Meesia longiseta Hedw.	α

MOSS	**Group**
Orthotrichum patens Bruch ex Brid.	α
Orthotrichum scanicum Groenvall	α
Orthotrichum stellatum Brid.	α
Ulota coarctata (P. Beauv.) Hammar	γ
Bryum uliginosum (Brid.) Bruch & Schimp.	γ
Amblystegium radicale (P. Beauv.) Schimp.	γ
Drepanocladus sendtneri (Schimp ex H. Müll.) Warnst.	α
Hamatocaulis vernicosus (Mitt.) Hedenäs	α
Pseudoleskea saviana (De Not.) Latzel	β
Haplocladium virginianum (Brid.) Broth.	α
Brachythecium laetum (Brid.) Schimp.	α
Homalothecium philipeanum (Spruce) BSG.	β
Myurella sibirica (Müll. Hal.) Reimers	α
Ctenidium molluscum (Hedw.) Mitt.	β
Hypnum fertile Sendtn.	β
Neckera pennata Hedw.	α
Buxbaumia aphylla Hedw.	γ
Buxbaumia viridis (Moug. ex Lam. & DC.) Brid. ex Nestl.	γ

FERN	**Group**
Lycopodium annotinum L.	α
Lycopodium clavatum L.	α
Asplenium cuneifolium Viv.	α
Dryopteris cristata (L.) A.Gray	α
Athyrium distentifolium Tausch ex Opiz	α

GYMNOSPERMS	**Group**
Picea omorika (Pančić) Purkyne	γ
Pinus heldreichii H.Christ	α
Pinus mugo Turra	α
Pinus nigra J.F.Arnold subsp. dalmatica (Vis.) Franco	α
Juniperus sabina L.	α
Taxus baccata L.	γ
Ephedra fragilis Desf. subsp. campylopoda (C.A.Mey.) Asch. & Graebn.	α

ANGIOSPERMS	**Group**
Eranthis hyemalis (L.) Salisb.	γ
Helleborus croaticus Martinis	β
Helleborus hercegovinus Martinis	β
Helleborus multifidus Vis.	β
Ranunculus auricomus L.	α
Castanea sativa Mill.	α
Quercus ilex L.	β
Quercus robur L.	α
Quercus trojana Webb	β
Betula pubescens Ehrh.	γ

ANGIOSPERMS	Group
Echium russicum J.F.Gmel.	β
Halacsya sendtneri (Boiss.) Dörfl.	γ
Corylus colurna L.	α
Corylus × colurnoides C.K.Schneid.	γ
Celtis tournefortii Lam.	α
Ulmus minor Mill.	α
Ribes multiflorum Kit. ex Roem. & Schult.	α
Ribes uva-crispa L.	α
Sedum album L.	α
Potentilla montenegrina Pant.	β
Prunus cocomilia Ten.	α
Pyrus amygdaliformis Vill.	β
Sorbus austriaca (Beck) Hedl.	β
Sorbus chamaemespilus (L.) Crantz	β
Sorbus x semipinata (Roth) Hedl.	γ
Calicotome villosa (Poir.) Link err.	γ
Chamaecytisus tommasinii (Vis.) Rothm.	β
Colutea arborescens L.	β
Lathyrus laevigatus (Waldst. & Kit.) Gren.	β
Vicia montenegrina Rohlena	β
Vicia oroboides Wulfen	β
Drosera rotundifolia L.	γ
Circaea alpina L.	β
Dictamnus albus L.	α
Rhus coriaria L.	γ
Acer heldreichii Orph. ex Boiss. subsp. visianii K. Maly	γ
Acer hyrcanum auct. balcan. non Fisch. & C.A.Mey.	γ
Ilex aquifolium L.	α
Rhamnus intermedius Steud. & Hochst.	β
Euphorbia esula L. subsp. esula	β
Euphorbia gregersenii K.Malý ex G.Beck	β
Euphorbia montenegrina (Bald.) K.Malý ex Rohlena	β
Chaerophyllum coloratum L.	β
Grafia golaka (Hacq.) Rchb.	α
Laser trilobum (L.) Borkh.	β
Peucedanum longifolium Waldst. & Kit.	β
Physospermum cornubiense (L.) DC.	β
Physospermum verticillatum (Waldst. & Kit.) Vis.	β
Pimpinella serbica (Vis.) Benth. & Hook.f. ex Drude	α
Paeonia mascula (L.) Mill.	α
Viola beckiana Fiala	α
Viola biflora L.	β
Fumana bonapartei Maire & Petitm.	β
Cardamine kitaibelii Becherer	β
Cardamine trifolia L.	β
Populus canescens (Aiton) Sm.	β

ANGIOSPERMS	Group
Salix pentandra L.	γ
Salix triandra L.	α
Daphne blagayana Freyer	α
Daphne cneorum L.	α
Daphne laureola L.	α
Arctostaphylos uva-ursi (L.) Spreng.	γ
Rhododendron hirsutum L.	β
Vaccinium myrtillus L.	β
Vaccinium vitis-idaea L.	α
Moneses uniflora (L.) A.Gray	α
Pyrola chlorantha Sw.	γ
Pyrola rotundifolia L.	α
Cyclamen hederifolium Aiton	α
Cyclamen purpurascens Mill.	β
Cyclamen repandum Sibth. & Sm.	β
Dianthus giganteus dUrv. subsp. croaticus (Borbás) Tutin	β
Lonicera alpigena L. subsp. formanekiana (Halácsy) Hayek	β
Lonicera glutinosa Vis.	β
Viburnum maculatum Pant.	β
Dipsacus pilosus L.	α
Knautia dinarica (Murb.) Borbás	β
Knautia sarajevensis (Beck) Szabó	β
Olea europaea L. var. sylvestris Brot.	α
Phillyrea latifolia L.	β
Mandragora officinarum L.	γ
Digitalis ferruginea L.	β
Digitalis lanata Ehrh.	β
Melampyrum fimbriatum Vandas	β
Melampyrum hoermannianum K.Malý	β
Melampyrum trichocalycinum Vandas	β
Scrophularia bosniaca Beck	β
Tozzia alpina L. subsp. carpathica (Woł.) Dostál	β
Veronica scardica Griseb.	β
Acanthus balcanicus Heywood & I.Richardson	β
Vitex agnus-castus L.	α
Acinos orontius (K. Malý) Šilić	β
Lamium orvala L.	β
Salvia brachyodon Vandas	α
Satureja horvatii Šilić	α
Satureja subspicata Vis. subsp. subspicata (incl. In Satureja montana L. subsp. illyrica Nyman)	α
Stachys serbica Pančić	β
Adenophora lilifolia (L.) Ledeb. ex A.DC.	α
Campanula latifolia L.	β
Campanula trichocalycina Ten.	α
Arnica montana L.	α